FIG.1

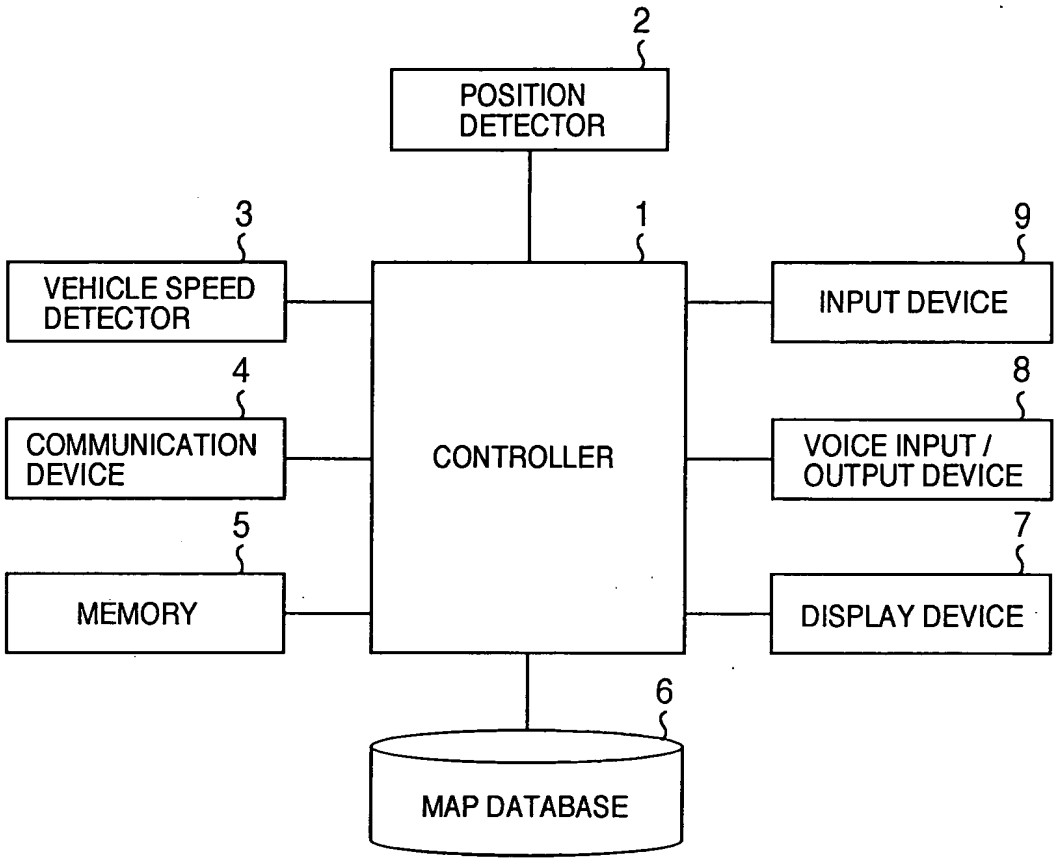

2
POSITION DETECTOR
3
VEHICLE SPEED DETECTOR
1
9
INPUT DEVICE
4
COMMUNICATION DEVICE
CONTROLLER
8
VOICE INPUT / OUTPUT DEVICE
5
MEMORY
7
DISPLAY DEVICE
6
MAP DATABASE

FIG.2

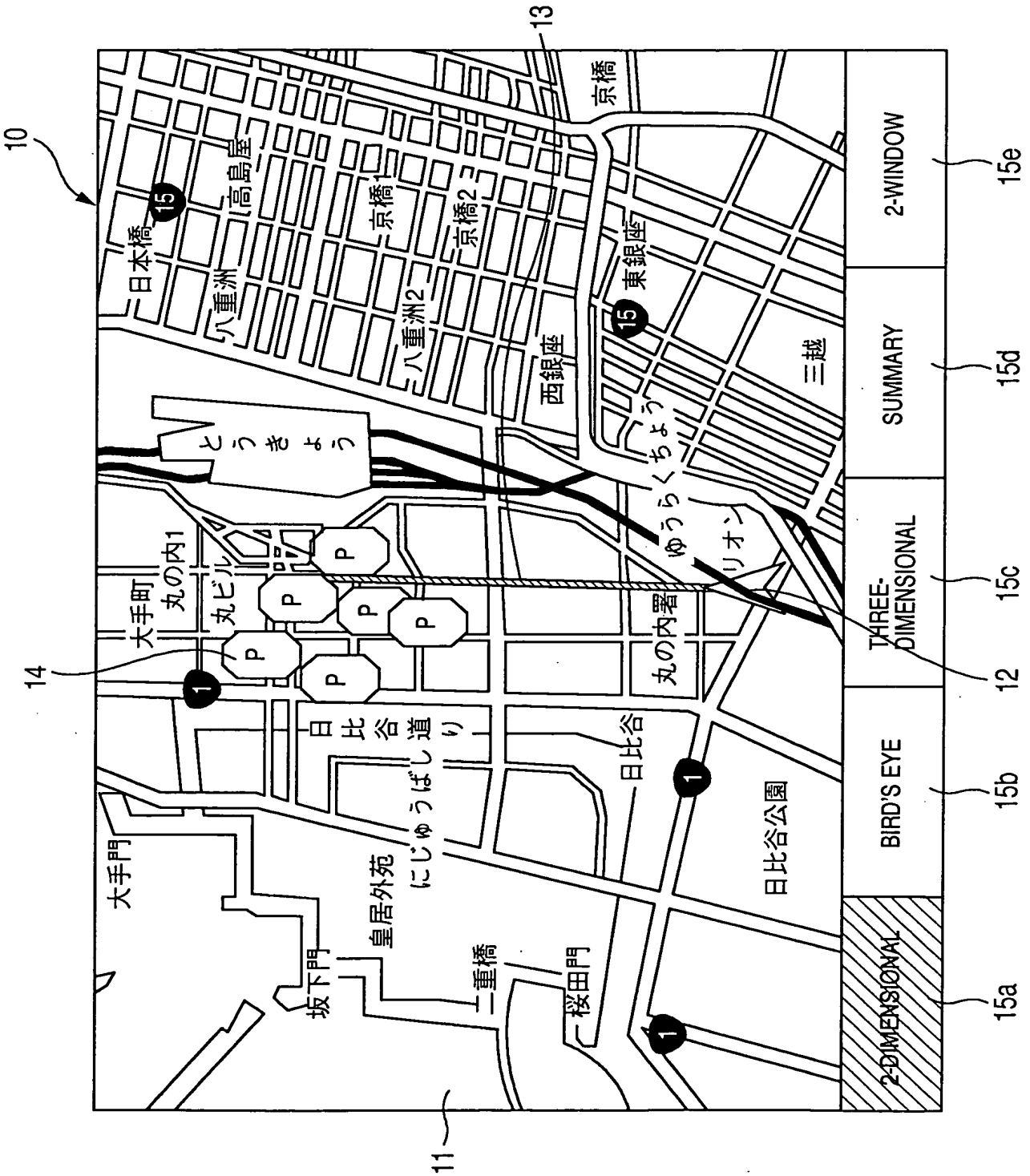

10
11
12
13
14
15a
15b
15c
15d
15e
2-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
日本橋
高島屋
八重洲
京橋1
京橋2
八重洲2
京橋
東銀座
西銀座
三越
丸の内1
丸ビル
大手町
日比谷道り
日比谷
丸の内署
ゆうらくちょう
リオン
日比谷公園
大手門
坂下門
皇居外苑
にじゅうばし
二重橋
桜田門

FIG.3

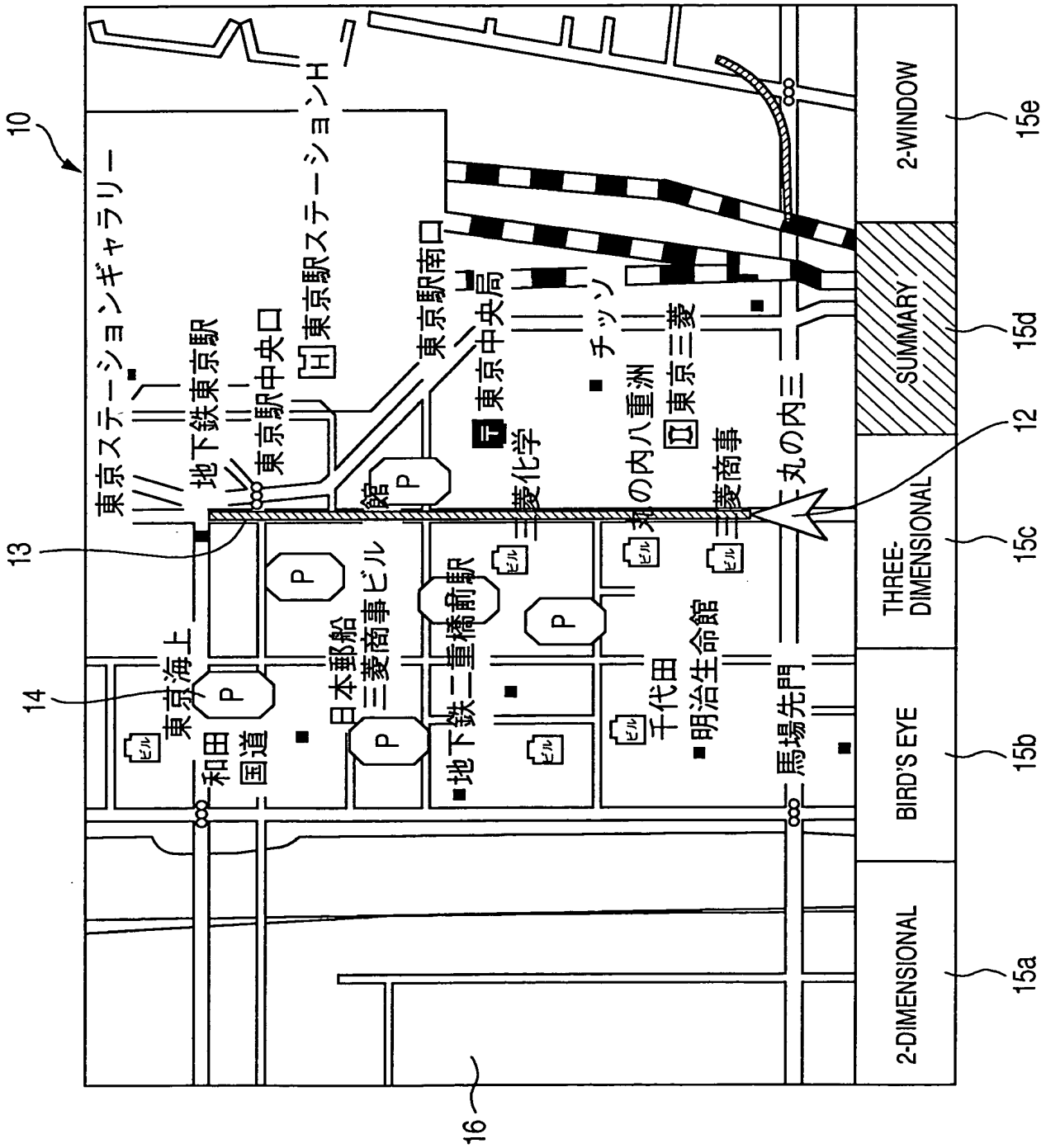

10
13
14
16
東京ステーションギャラリー
地下鉄東京駅
東京駅中央口
東京駅ステーションH
東京駅南口
東京中央局
チッソ
丸の内八重洲
東京三菱
丸の内三
三菱化学
三菱商事
館
日本郵船
三菱商事ビル
地下鉄二重橋前駅
千代田
明治生命館
馬場先門
東京海上
和田
国道
2-WINDOW
SUMMARY
THREE-
DIMENSIONAL
BIRD'S EYE
2-DIMENSIONAL
12
15a
15b
15c
15d
15e

FIG.4A

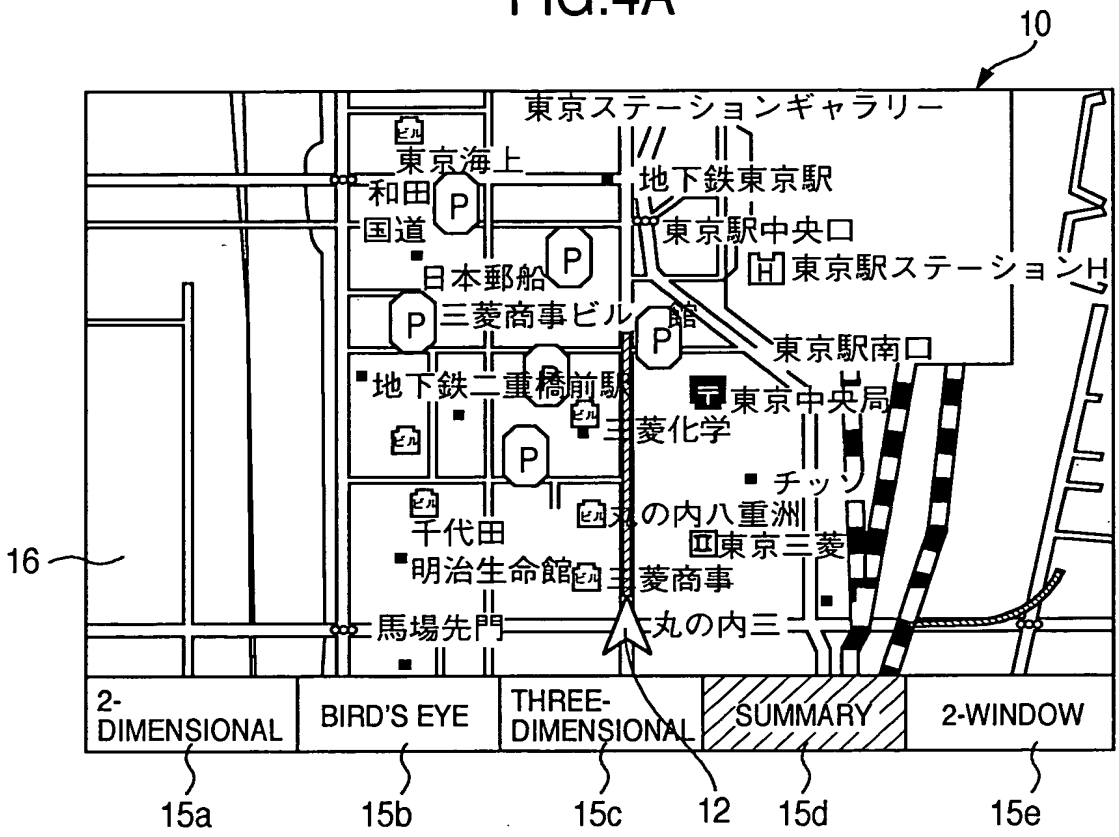

10
東京ステーションギャラリー
東京海上
地下鉄東京駅
和田
国道
東京駅中央口
日本郵船
東京駅ステーションH
三菱商事ビル
東京駅南口
地下鉄二重橋前駅
東京中央局
三菱化学
チッソ
千代田
丸の内八重洲
東京三菱
明治生命館
三菱商事
馬場先門
丸の内三
16
2-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
15b
15c
12
15d
15e

FIG.4B

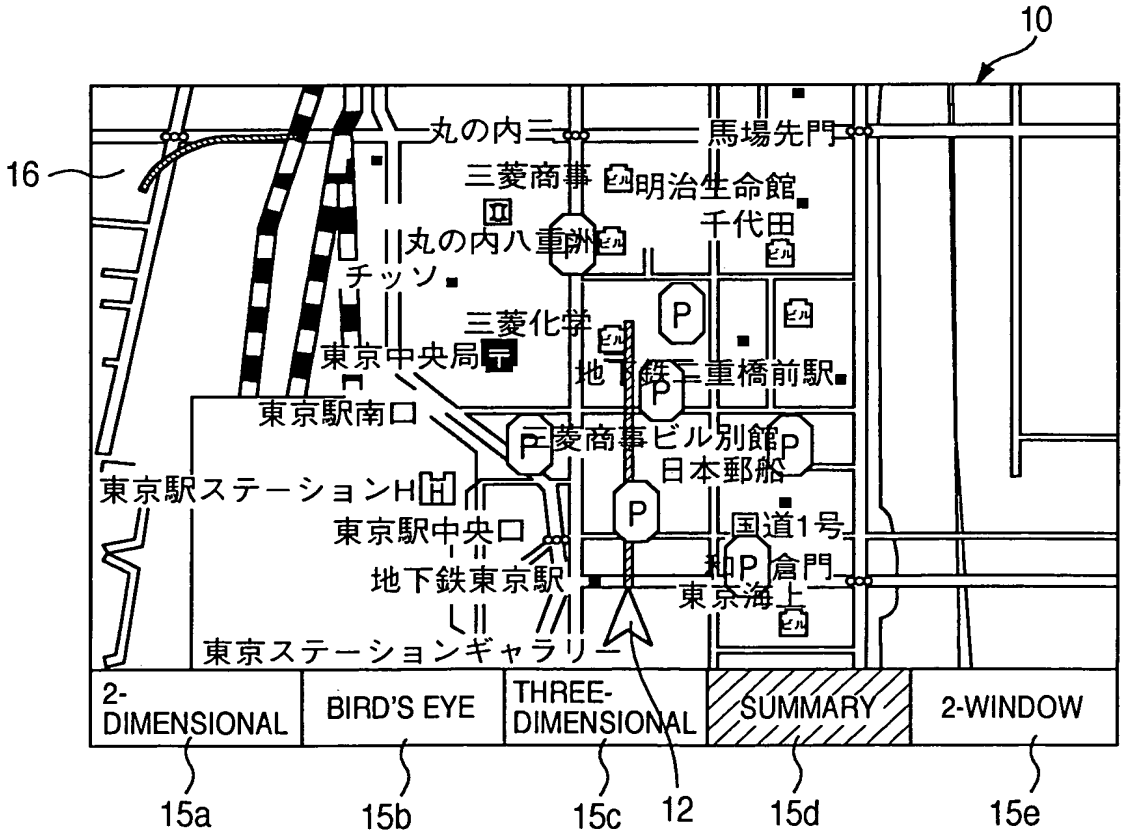

10
丸の内三
馬場先門
16
三菱商事
明治生命館
千代田
丸の内八重洲
チッソ
三菱化学
東京中央局
地下鉄二重橋前駅
東京駅南口
三菱商事ビル別館
日本郵船
東京駅ステーションH
東京駅中央口
国道1号
地下鉄東京駅
東京海上
東京ステーションギャラリー
2-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
15b
15c
12
15d
15e

FIG.5A

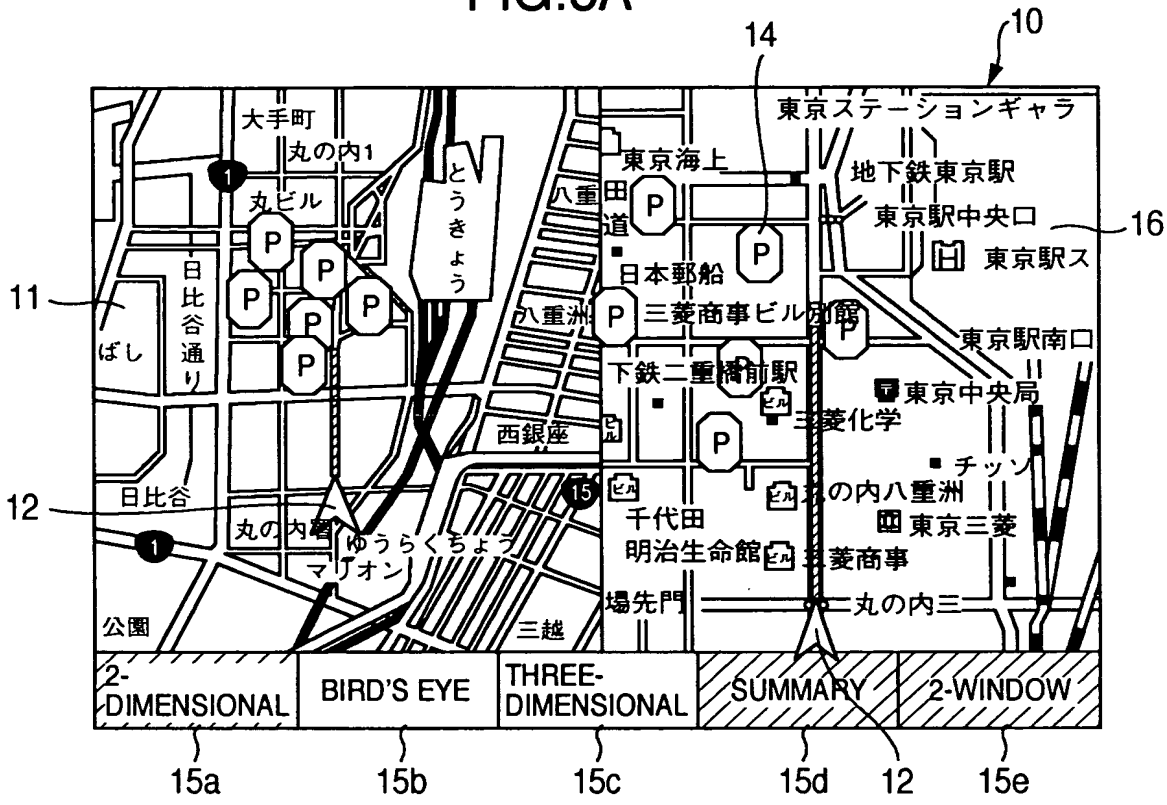

10
14
16
11
12
大手町
丸の内1
丸ビル
日比谷通り
ばし
日比谷
丸の内
ゆうらくちょう
マリオン
公園
とうきょう
八重洲
西銀座
三越
東京海上
日本郵船
東京ステーションギャラ
地下鉄東京駅
東京駅中央口
東京駅ス
三菱商事ビル別館
東京駅南口
下鉄二重橋前駅
東京中央局
三菱化学
チッソ
丸の内八重洲
東京三菱
千代田
明治生命館
菱商事
場先門
丸の内三
2-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
15b
15c
15d
12
15e

FIG.5B

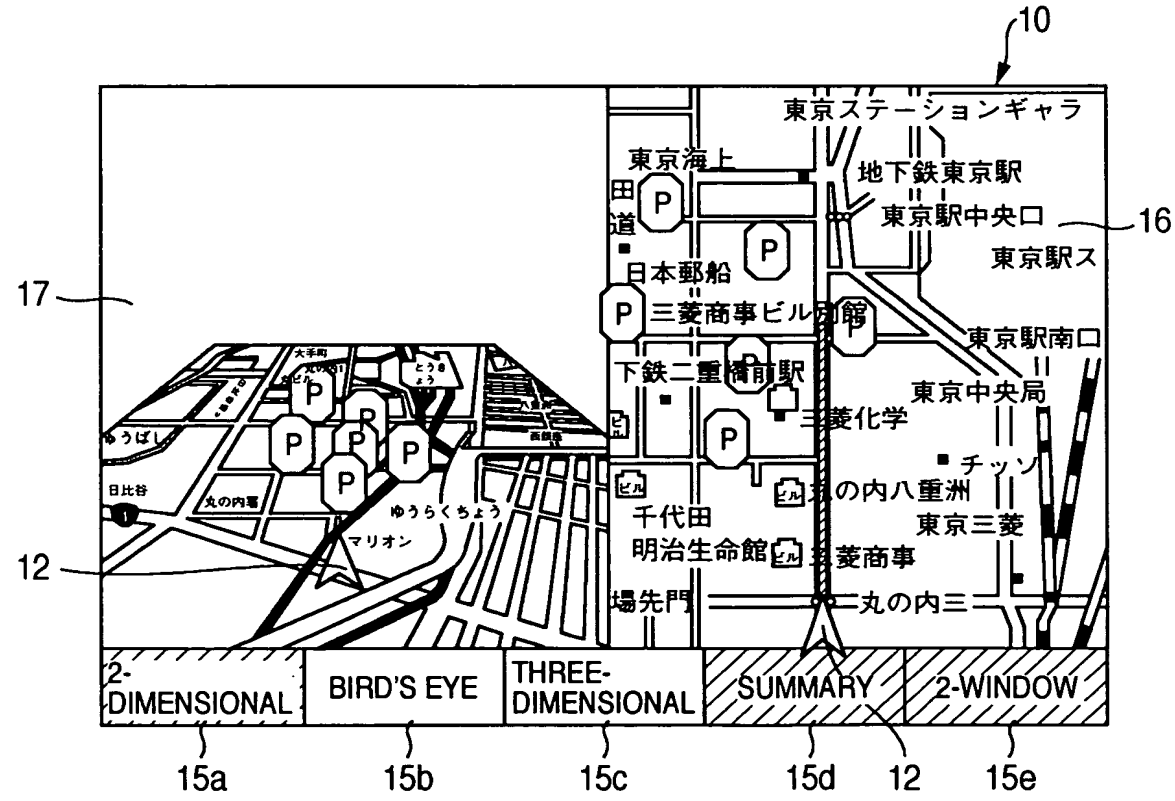

10
17
12
16
東京ステーションギャラ
地下鉄東京駅
東京駅中央口
東京駅ス
東京海上
日本郵船
三菱商事ビル別館
東京駅南口
下鉄二重橋前駅
東京中央局
三菱化学
チッソ
丸の内八重洲
東京三菱
千代田
明治生命館
菱商事
場先門
丸の内三
2-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
15b
15c
15d
12
15e

FIG.6

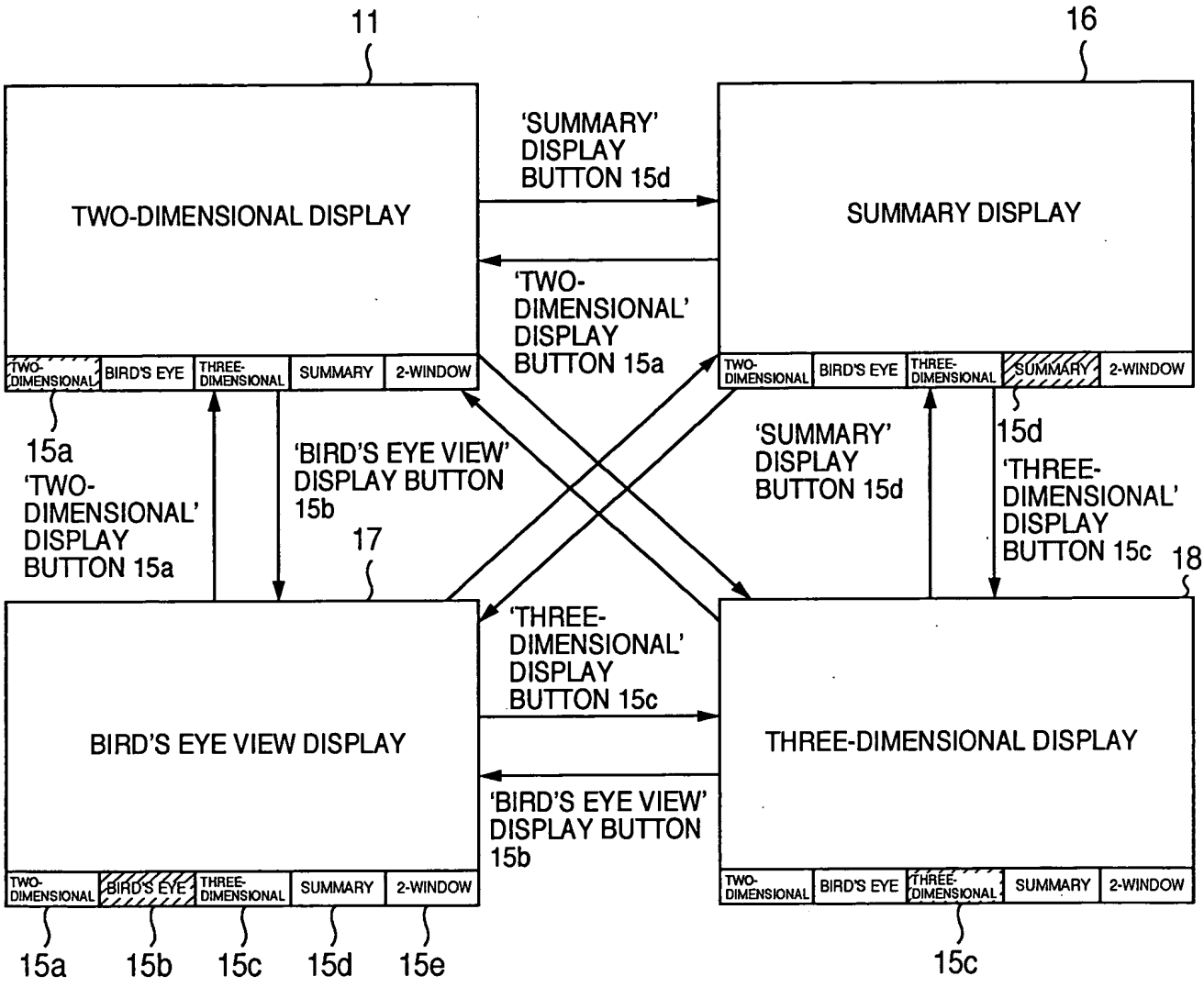

11
16
TWO-DIMENSIONAL DISPLAY
SUMMARY DISPLAY
'SUMMARY' DISPLAY BUTTON 15d
'TWO-DIMENSIONAL' DISPLAY BUTTON 15a
TWO-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
'TWO-DIMENSIONAL' DISPLAY BUTTON 15a
'BIRD'S EYE VIEW' DISPLAY BUTTON 15b
17
'SUMMARY' DISPLAY BUTTON 15d
15d
'THREE-DIMENSIONAL' DISPLAY BUTTON 15c
18
'THREE-DIMENSIONAL' DISPLAY BUTTON 15c
BIRD'S EYE VIEW DISPLAY
THREE-DIMENSIONAL DISPLAY
'BIRD'S EYE VIEW' DISPLAY BUTTON 15b
15a
15b
15c
15d
15e
15c

FIG.7

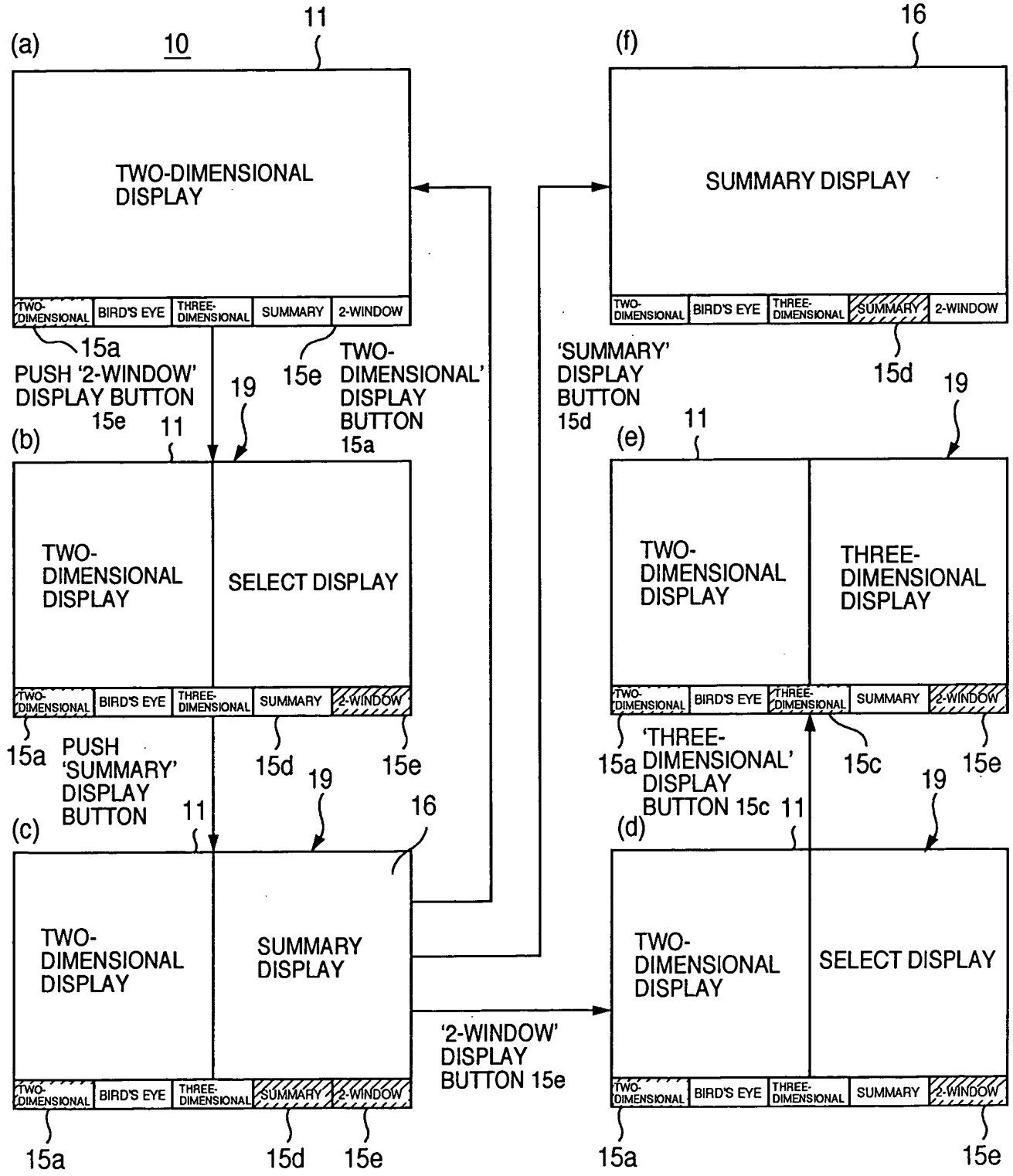

(a)
10
11
TWO-DIMENSIONAL DISPLAY
TWO-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
PUSH '2-WINDOW' DISPLAY BUTTON 15e
15e
TWO-DIMENSIONAL' DISPLAY BUTTON 15a
19
(b)
11
TWO-DIMENSIONAL DISPLAY
SELECT DISPLAY
15a
PUSH 'SUMMARY' DISPLAY BUTTON
15d
15e
19
11
16
(c)
TWO-DIMENSIONAL DISPLAY
SUMMARY DISPLAY
15a
15d
15e
'2-WINDOW' DISPLAY BUTTON 15e
(f)
16
SUMMARY DISPLAY
'SUMMARY' DISPLAY BUTTON 15d
15d
19
11
(e)
TWO-DIMENSIONAL DISPLAY
THREE-DIMENSIONAL DISPLAY
15a
'THREE-DIMENSIONAL' DISPLAY BUTTON 15c
15c
15e
19
11
(d)
TWO-DIMENSIONAL DISPLAY
SELECT DISPLAY
15a
15e

FIG.8

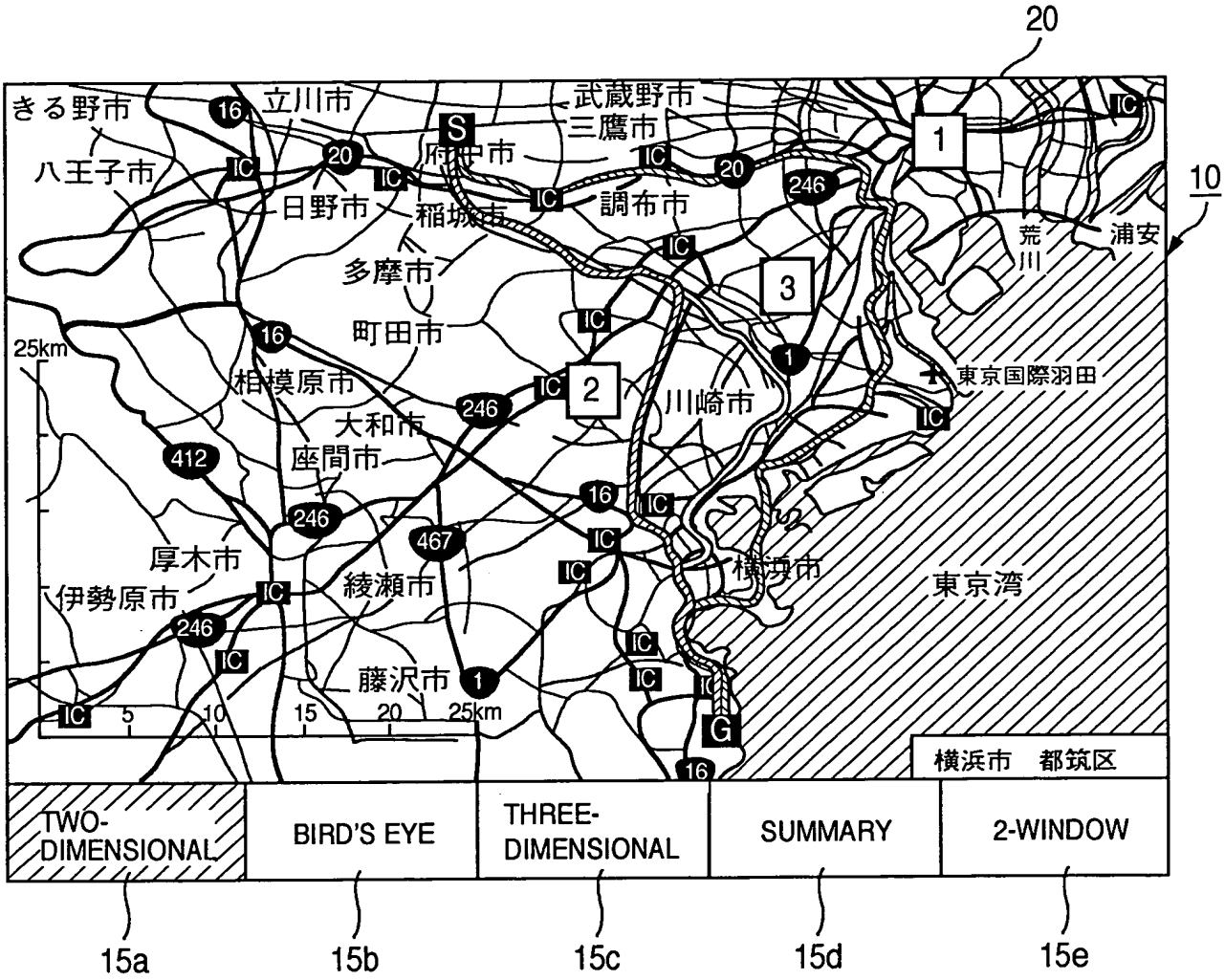

20
10
きる野市
立川市
武蔵野市
三鷹市
八王子市
府中市
日野市
稲城市
調布市
多摩市
町田市
相模原市
大和市
座間市
厚木市
伊勢原市
綾瀬市
藤沢市
川崎市
横浜市
東京湾
東京国際羽田
荒川
浦安
横浜市　都筑区
25km
5
10
15
20
25km
TWO-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
15b
15c
15d
15e

FIG.9

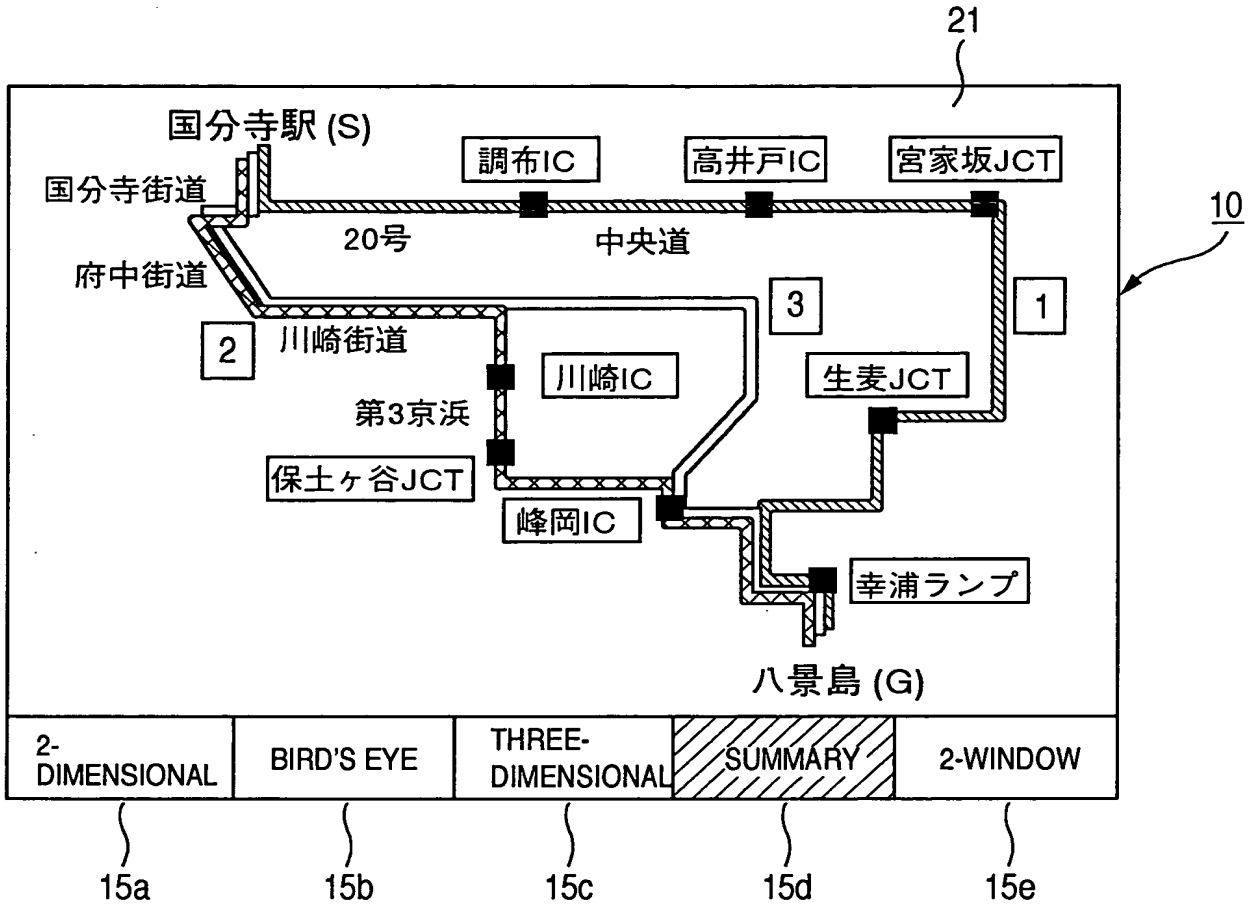

21
国分寺駅 (S)
調布IC
高井戸IC
宮家坂JCT
国分寺街道
20号
中央道
10
府中街道
3
1
2
川崎街道
川崎IC
生麦JCT
第3京浜
保土ヶ谷JCT
峰岡IC
幸浦ランプ
八景島 (G)
2-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
15b
15c
15d
15e

FIG.10

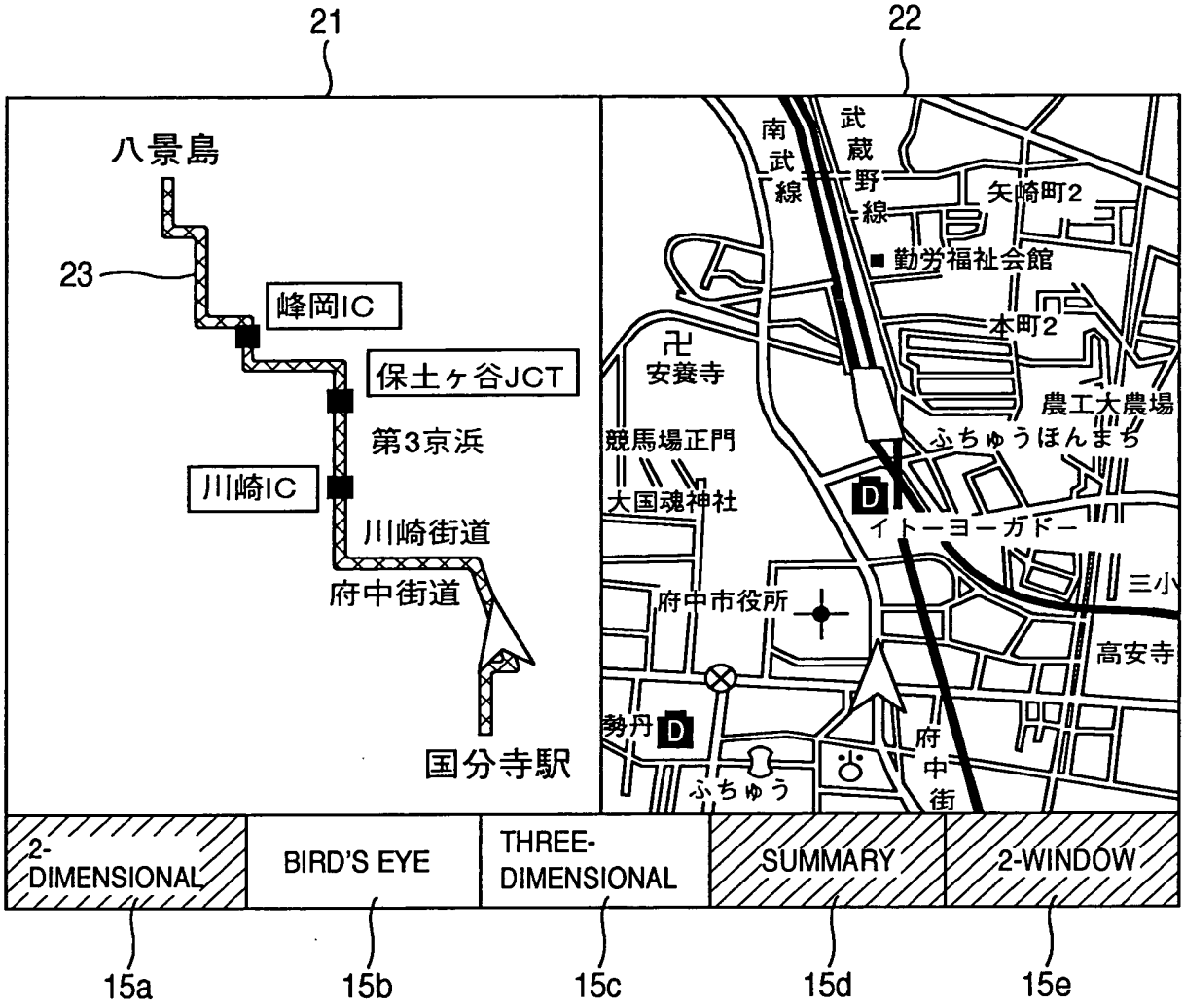

21
22
八景島
23
峰岡IC
保土ヶ谷JCT
第3京浜
川崎IC
川崎街道
府中街道
国分寺駅
南武線
武蔵野線
矢崎町2
勤労福祉会館
本町2
安養寺
農工大農場
ふちゅうほんまち
競馬場正門
大国魂神社
イトーヨーカドー
府中市役所
三小
高安寺
勢丹
ふちゅう
府中街
2-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
15b
15c
15d
15e

FIG.11

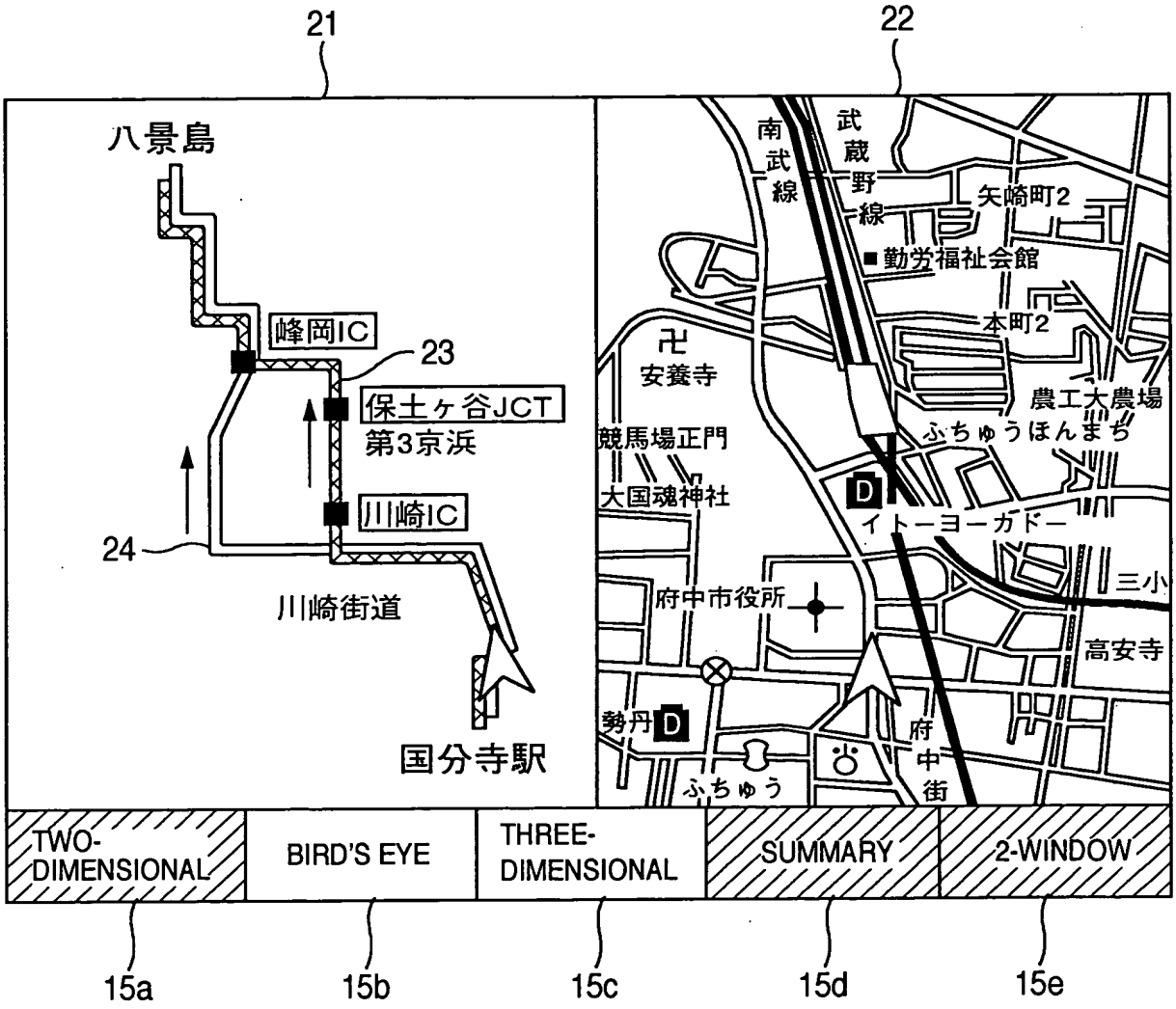

21
22
八景島
峰岡IC
23
保土ヶ谷JCT
第3京浜
川崎IC
24
川崎街道
国分寺駅
南武線
武蔵野線
矢崎町2
勤労福祉会館
本町2
安養寺
農工大農場
ふちゅうほんまち
競馬場正門
大国魂神社
イトーヨーカドー
府中市役所
三小
高安寺
勢丹
ふちゅう
府中街
TWO-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
15b
15c
15d
15e

FIG.12

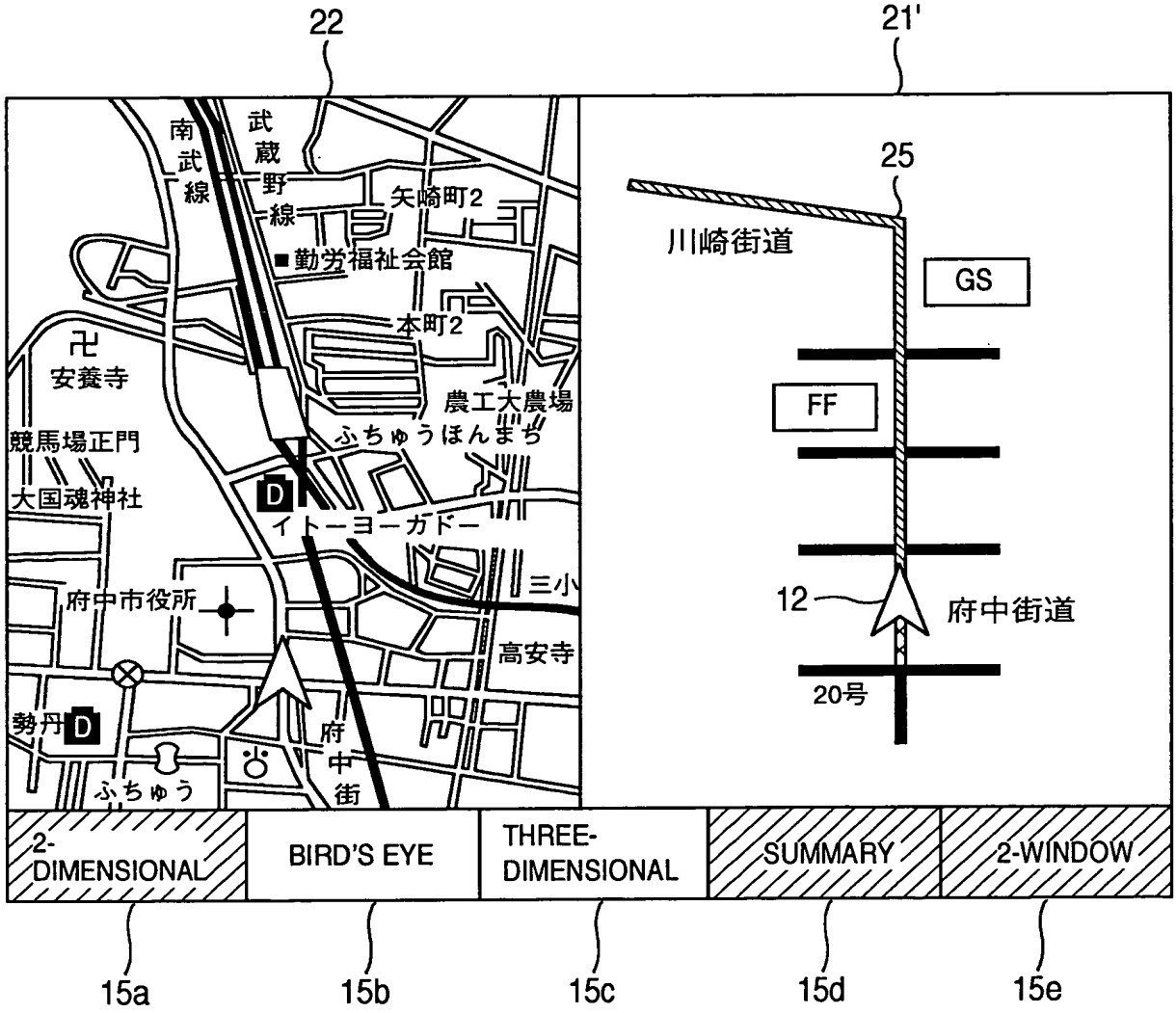

22
21'
南武線
武蔵野線
矢崎町2
■勤労福祉会館
本町2
安養寺
農工大農場
ふちゅうほんまち
競馬場正門
大国魂神社
D
イトーヨーカドー
三小
府中市役所
高安寺
勢丹
D
ふちゅう
府中街
25
川崎街道
GS
FF
12
府中街道
20号
2-DIMENSIONAL
BIRD'S EYE
THREE-DIMENSIONAL
SUMMARY
2-WINDOW
15a
15b
15c
15d
15e

FIG.1 3

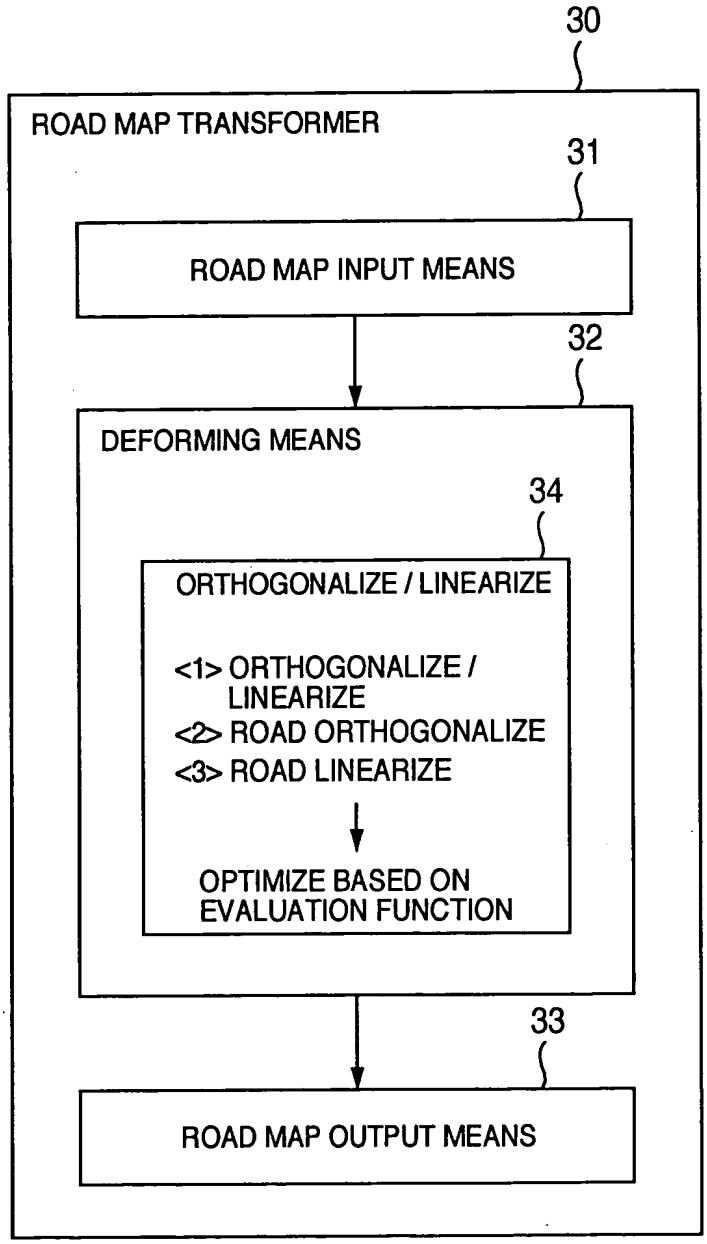

30
ROAD MAP TRANSFORMER
31
ROAD MAP INPUT MEANS
32
DEFORMING MEANS
34
ORTHOGONALIZE / LINEARIZE
<1> ORTHOGONALIZE / LINEARIZE
<2> ROAD ORTHOGONALIZE
<3> ROAD LINEARIZE
OPTIMIZE BASED ON EVALUATION FUNCTION
33
ROAD MAP OUTPUT MEANS

FIG.14

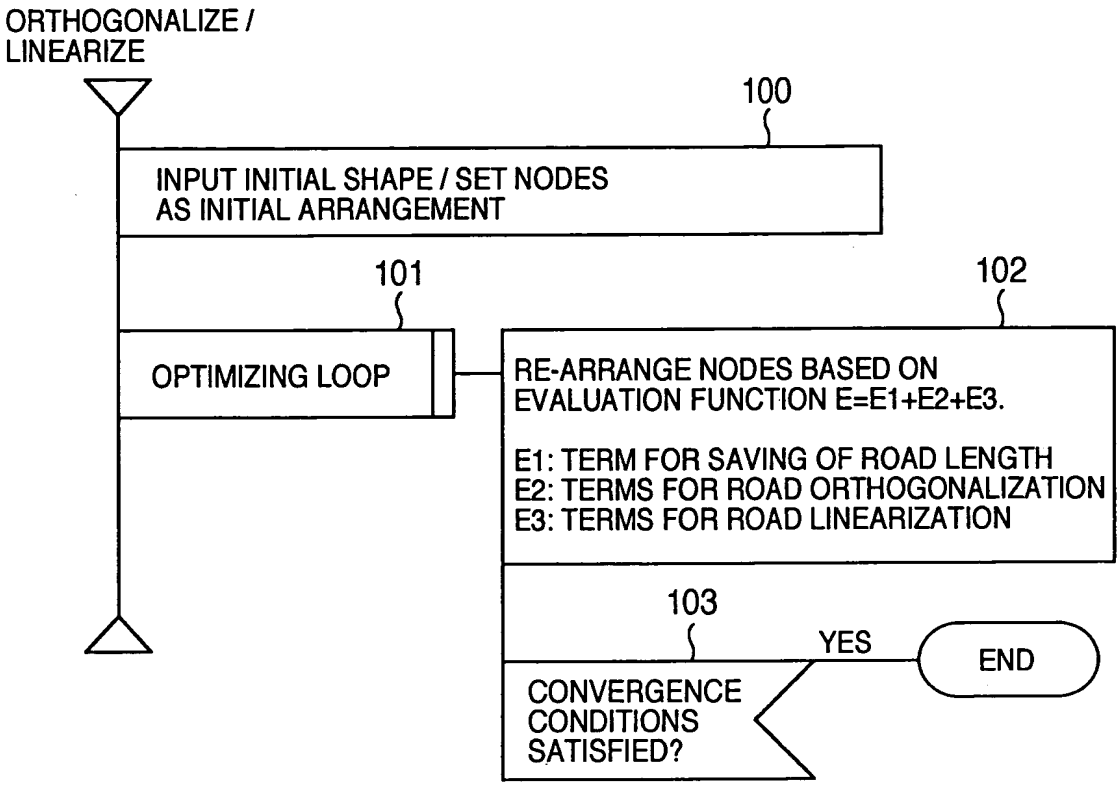

ORTHOGONALIZE / LINEARIZE
100
INPUT INITIAL SHAPE / SET NODES AS INITIAL ARRANGEMENT
101
OPTIMIZING LOOP
102
RE-ARRANGE NODES BASED ON EVALUATION FUNCTION E=E1+E2+E3.
E1: TERM FOR SAVING OF ROAD LENGTH
E2: TERMS FOR ROAD ORTHOGONALIZATION
E3: TERMS FOR ROAD LINEARIZATION
103
YES
END
CONVERGENCE CONDITIONS SATISFIED?

FIG.15

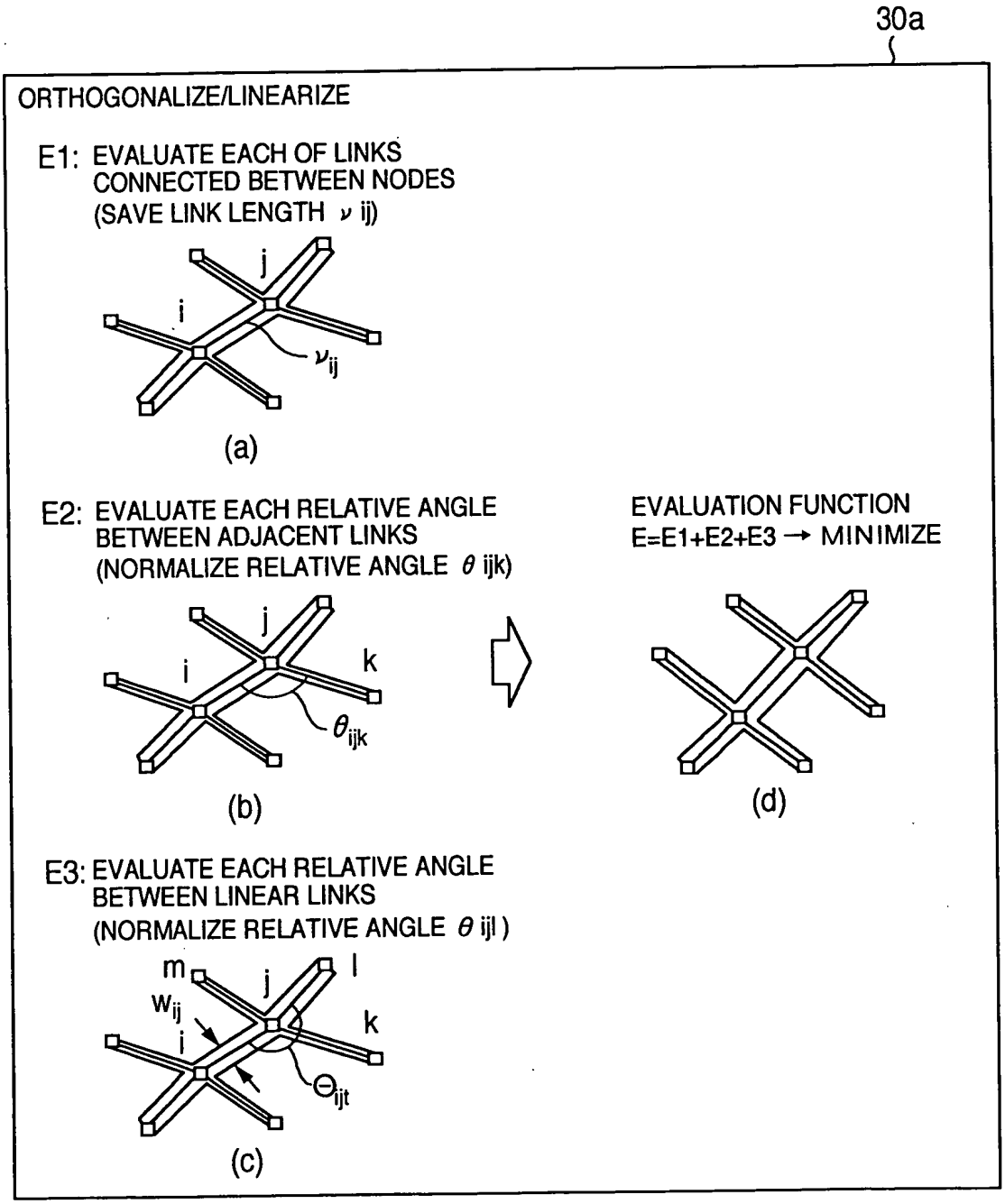

30a
ORTHOGONALIZE/LINEARIZE
E1: EVALUATE EACH OF LINKS CONNECTED BETWEEN NODES (SAVE LINK LENGTH ν ij)
j
i
ν_{ij}
(a)
E2: EVALUATE EACH RELATIVE ANGLE BETWEEN ADJACENT LINKS (NORMALIZE RELATIVE ANGLE θ ijk)
j
i
k
θ_{ijk}
(b)
EVALUATION FUNCTION
E=E1+E2+E3 → MINIMIZE
(d)
E3: EVALUATE EACH RELATIVE ANGLE BETWEEN LINEAR LINKS (NORMALIZE RELATIVE ANGLE θ ijl)
m
j
l
w_{ij}
i
k
Θ_{ijt}
(c)

FIG.16

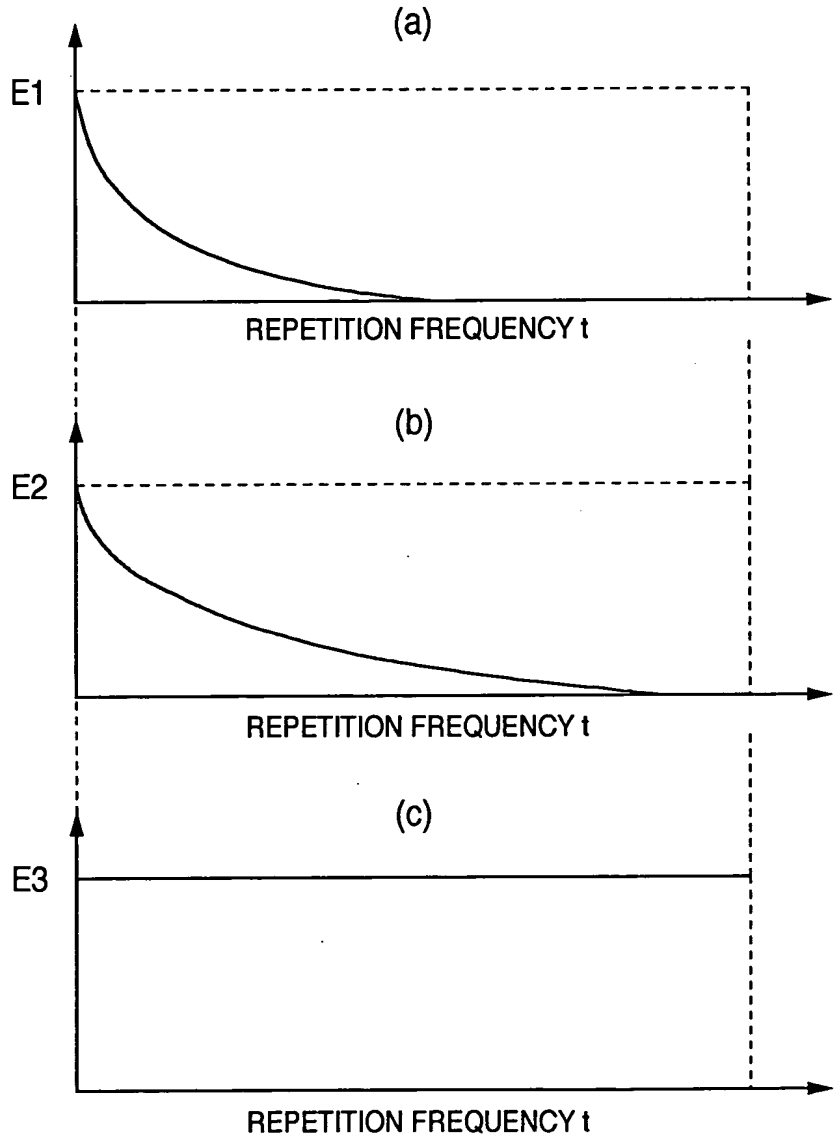

(a)
E1
REPETITION FREQUENCY t
(b)
E2
REPETITION FREQUENCY t
(c)
E3
REPETITION FREQUENCY t

FIG.17

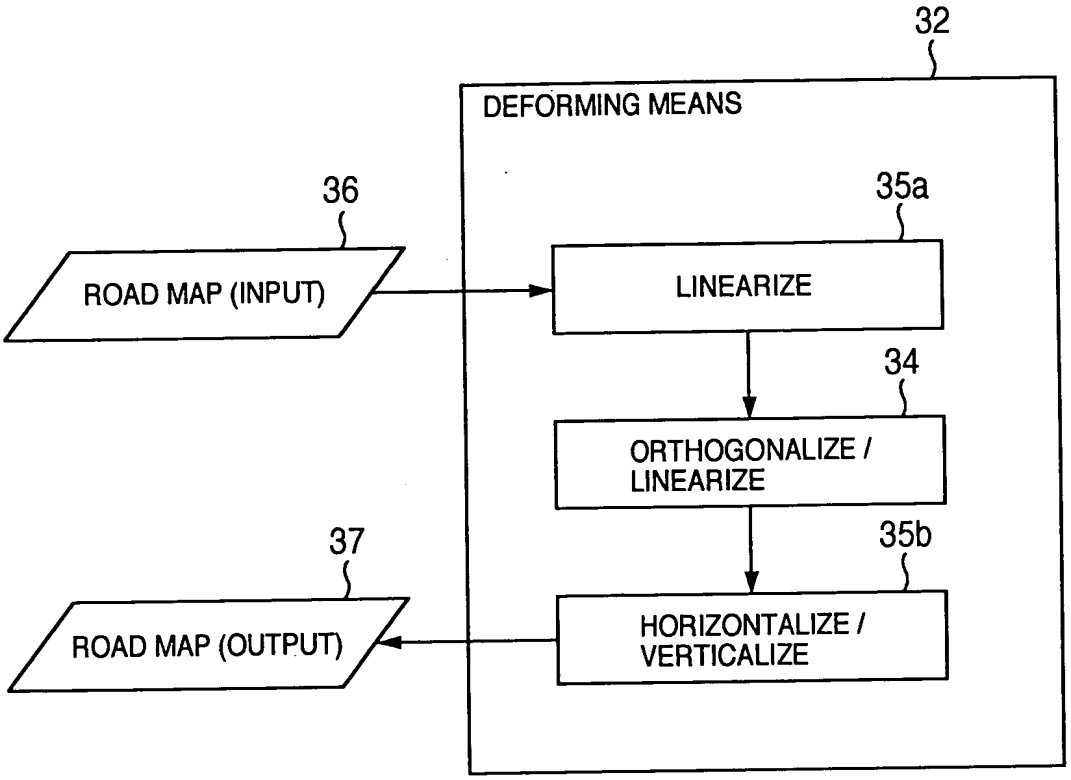

32
DEFORMING MEANS
36
ROAD MAP (INPUT)
35a
LINEARIZE
34
ORTHOGONALIZE / LINEARIZE
37
ROAD MAP (OUTPUT)
35b
HORIZONTALIZE / VERTICALIZE

FIG.18

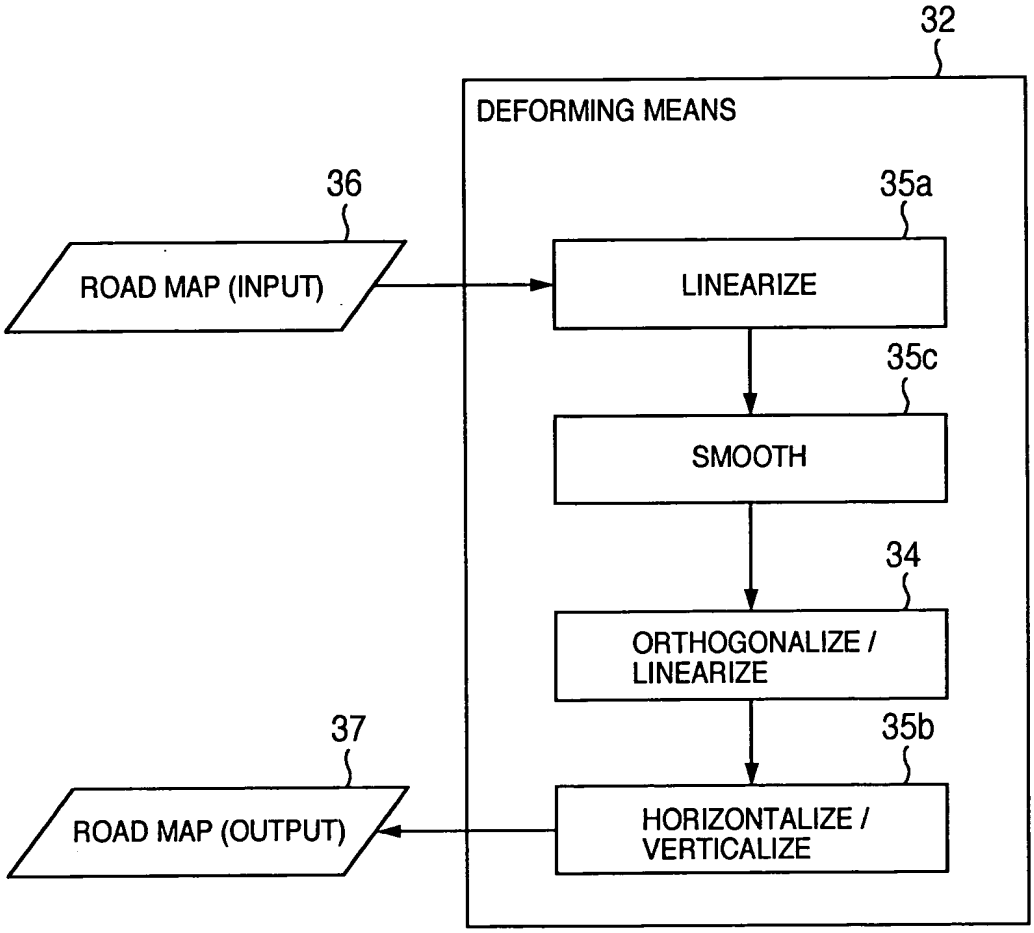

32
DEFORMING MEANS
36
ROAD MAP (INPUT)
35a
LINEARIZE
35c
SMOOTH
34
ORTHOGONALIZE / LINEARIZE
35b
HORIZONTALIZE / VERTICALIZE
37
ROAD MAP (OUTPUT)

FIG.19

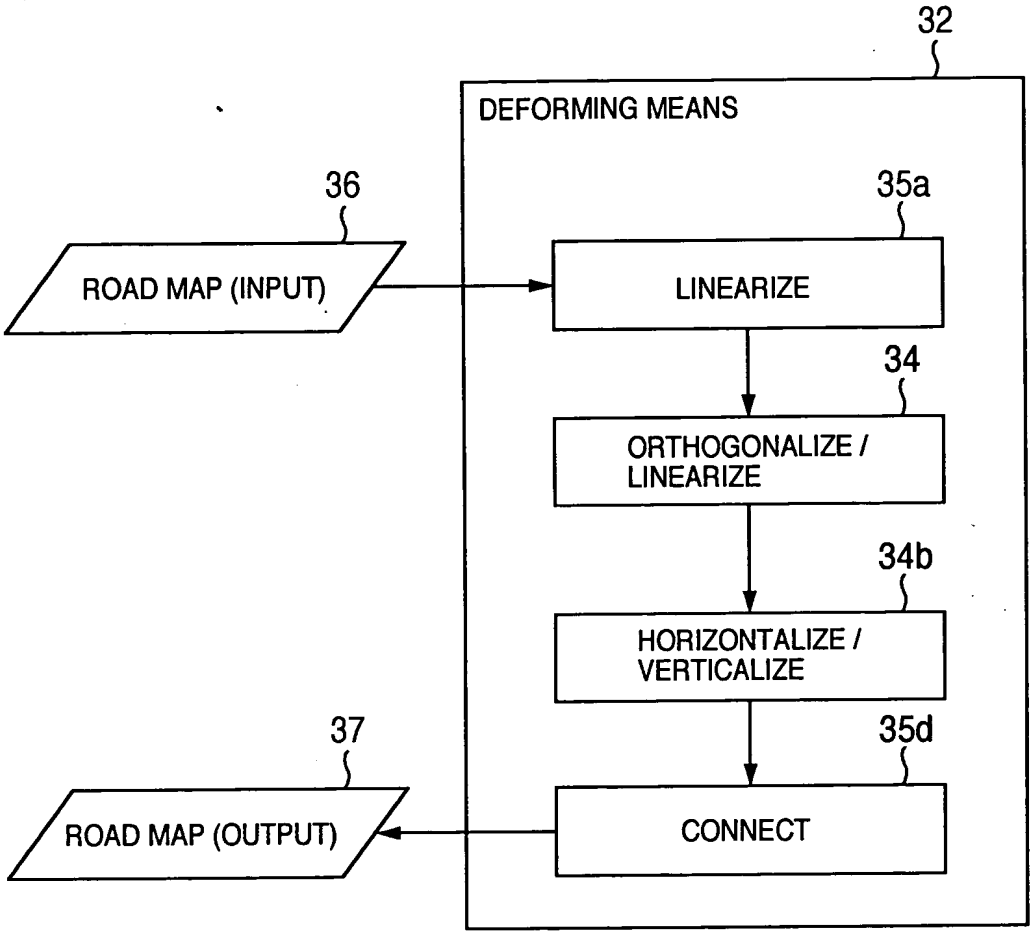

32
DEFORMING MEANS
36
ROAD MAP (INPUT)
35a
LINEARIZE
34
ORTHOGONALIZE / LINEARIZE
34b
HORIZONTALIZE / VERTICALIZE
35d
CONNECT
37
ROAD MAP (OUTPUT)

FIG.20

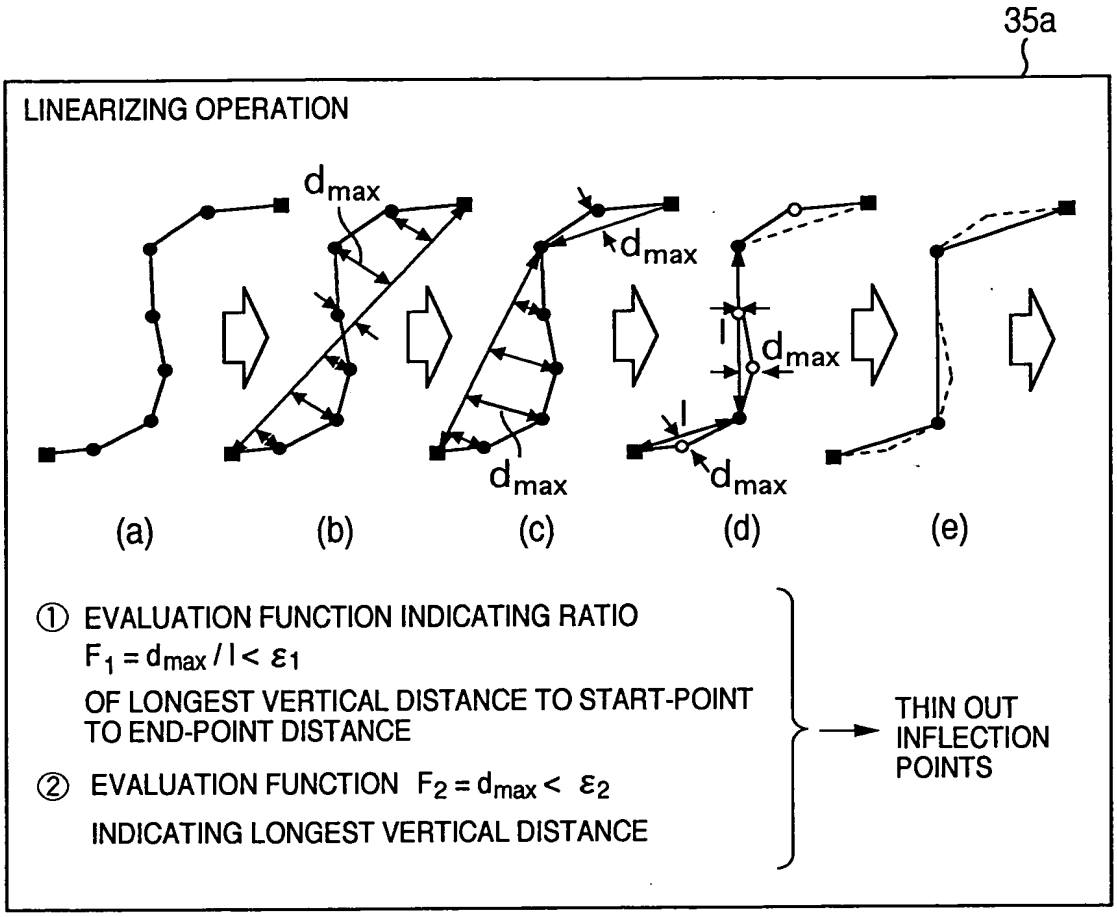

35a
LINEARIZING OPERATION
d_{max}
d_{max}
d_{max}
d_{max}
d_{max}
l
l
(a)
(b)
(c)
(d)
(e)
① EVALUATION FUNCTION INDICATING RATIO
$F_1 = d_{max} / l < \varepsilon_1$
OF LONGEST VERTICAL DISTANCE TO START-POINT TO END-POINT DISTANCE
② EVALUATION FUNCTION $F_2 = d_{max} < \varepsilon_2$
INDICATING LONGEST VERTICAL DISTANCE
THIN OUT INFLECTION POINTS

FIG.21

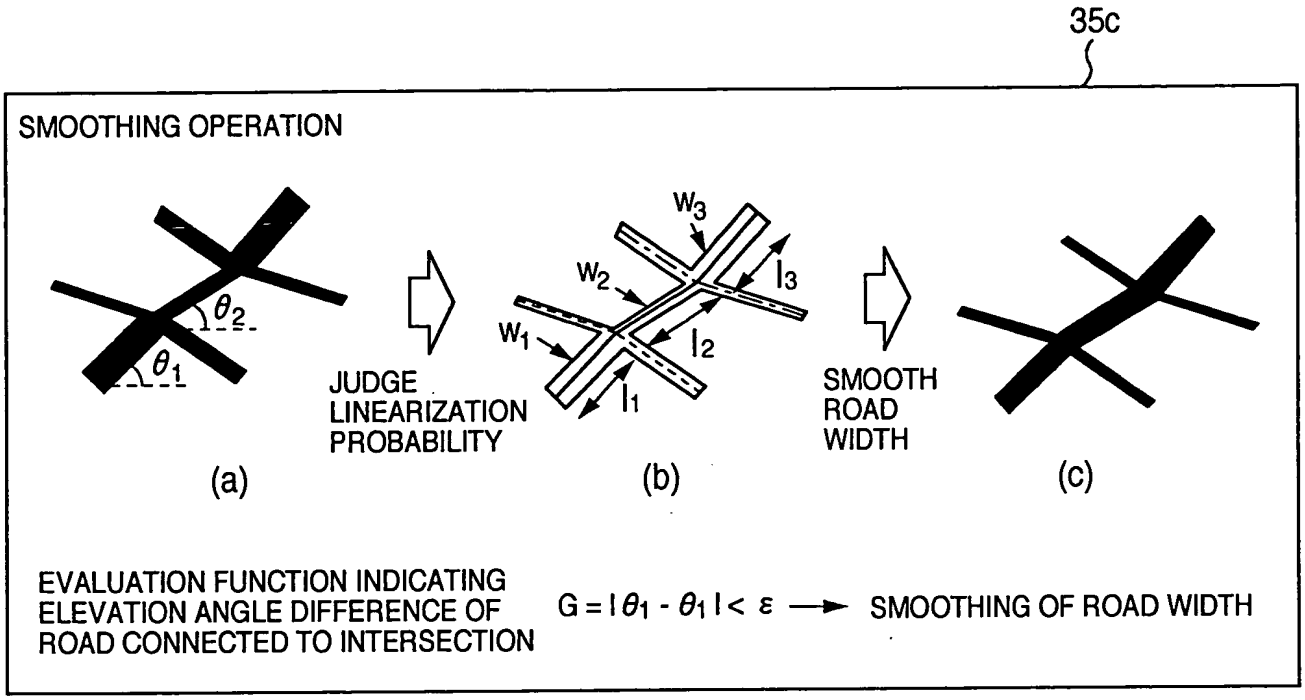

35c
SMOOTHING OPERATION
θ2
θ1
JUDGE
LINEARIZATION
PROBABILITY
W3
W2
W1
l3
l2
l1
SMOOTH
ROAD
WIDTH
(a)
(b)
(c)
EVALUATION FUNCTION INDICATING
ELEVATION ANGLE DIFFERENCE OF
ROAD CONNECTED TO INTERSECTION
G = | θ1 - θ1 | < ε
SMOOTHING OF ROAD WIDTH

FIG.22A

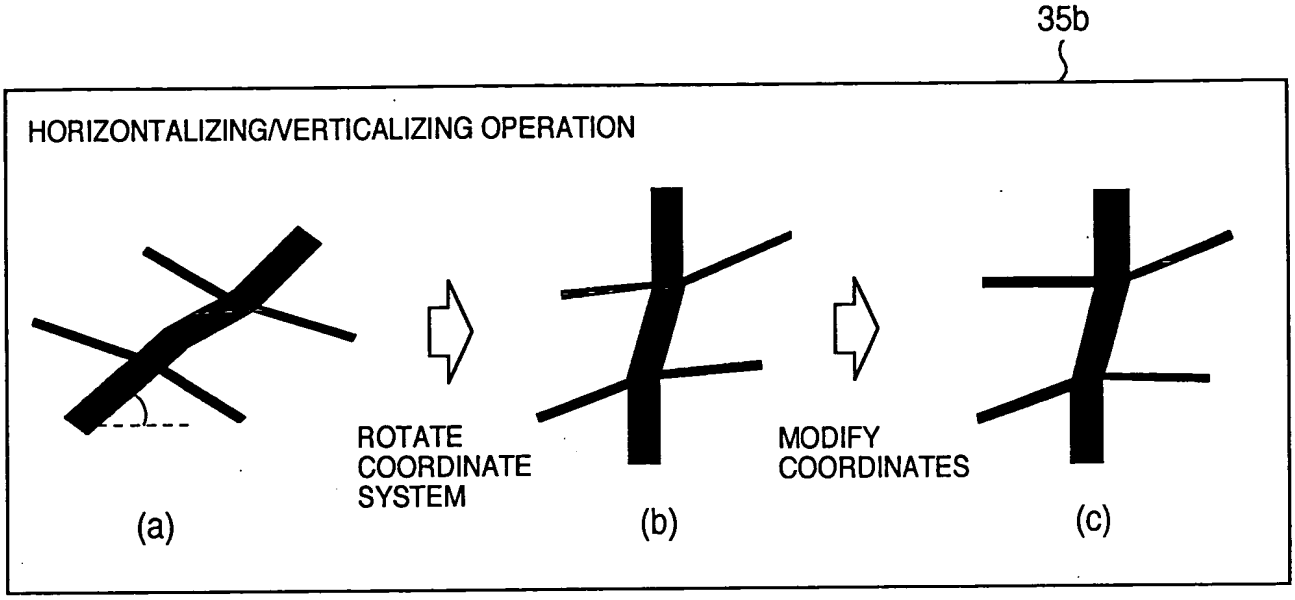


FIG.22B

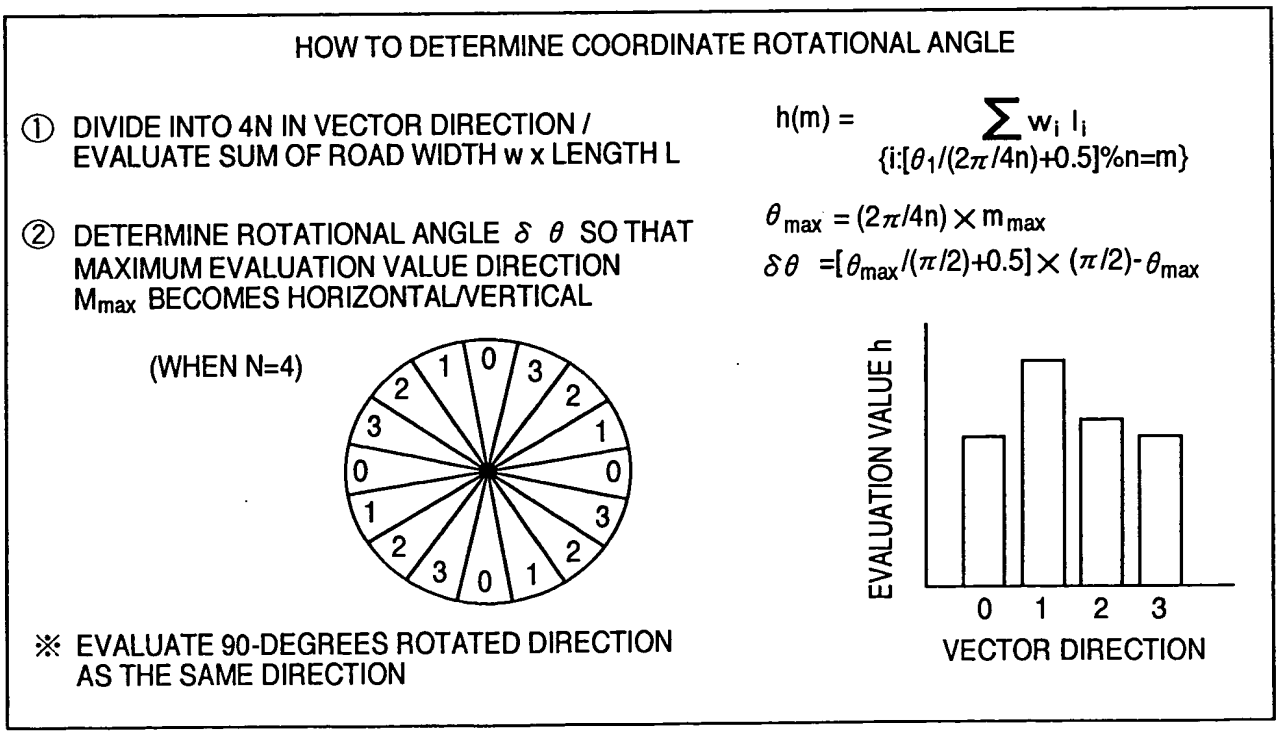


FIG.23

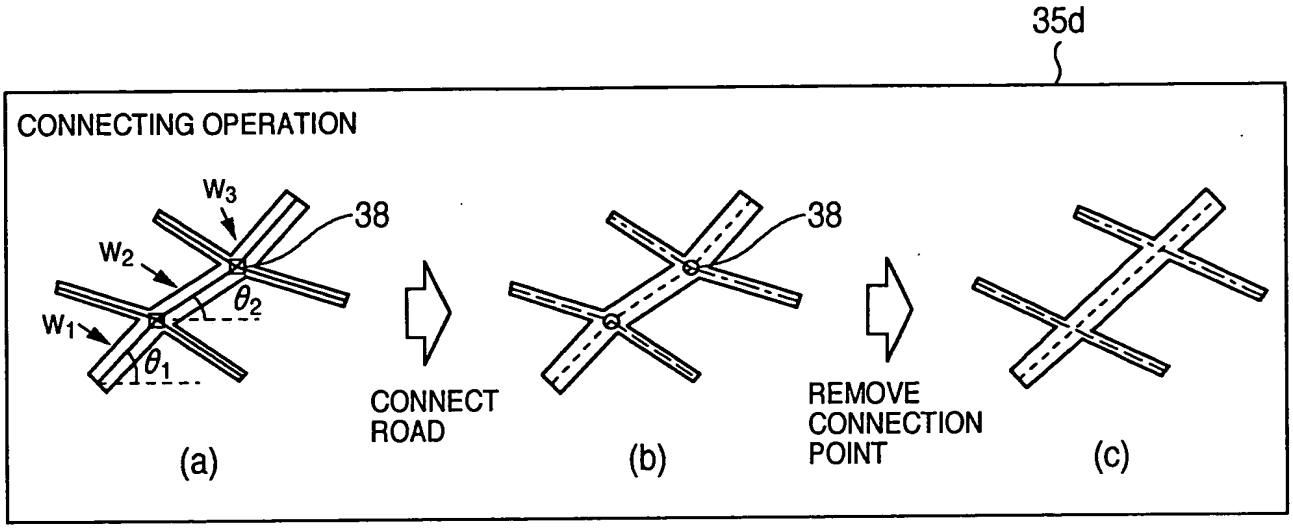
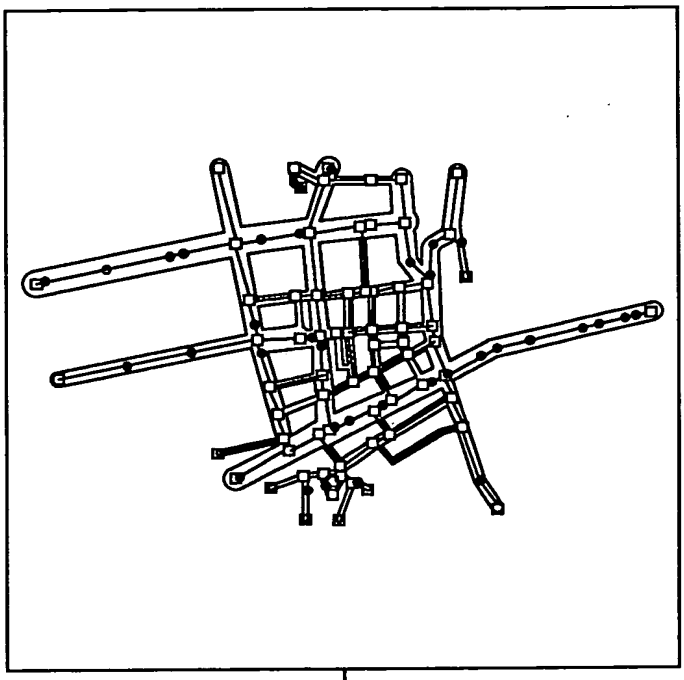

35d
CONNECTING OPERATION
W3
W2
W1
θ2
θ1
38
38
CONNECT ROAD
REMOVE CONNECTION POINT
(a)
(b)
(c)

FIG.24

(a)



LINEARIZE

(b)

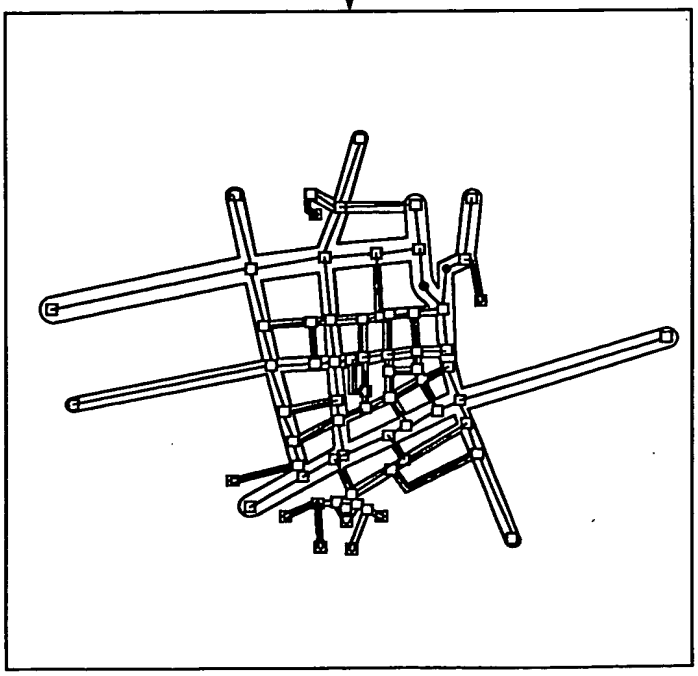


FIG.25

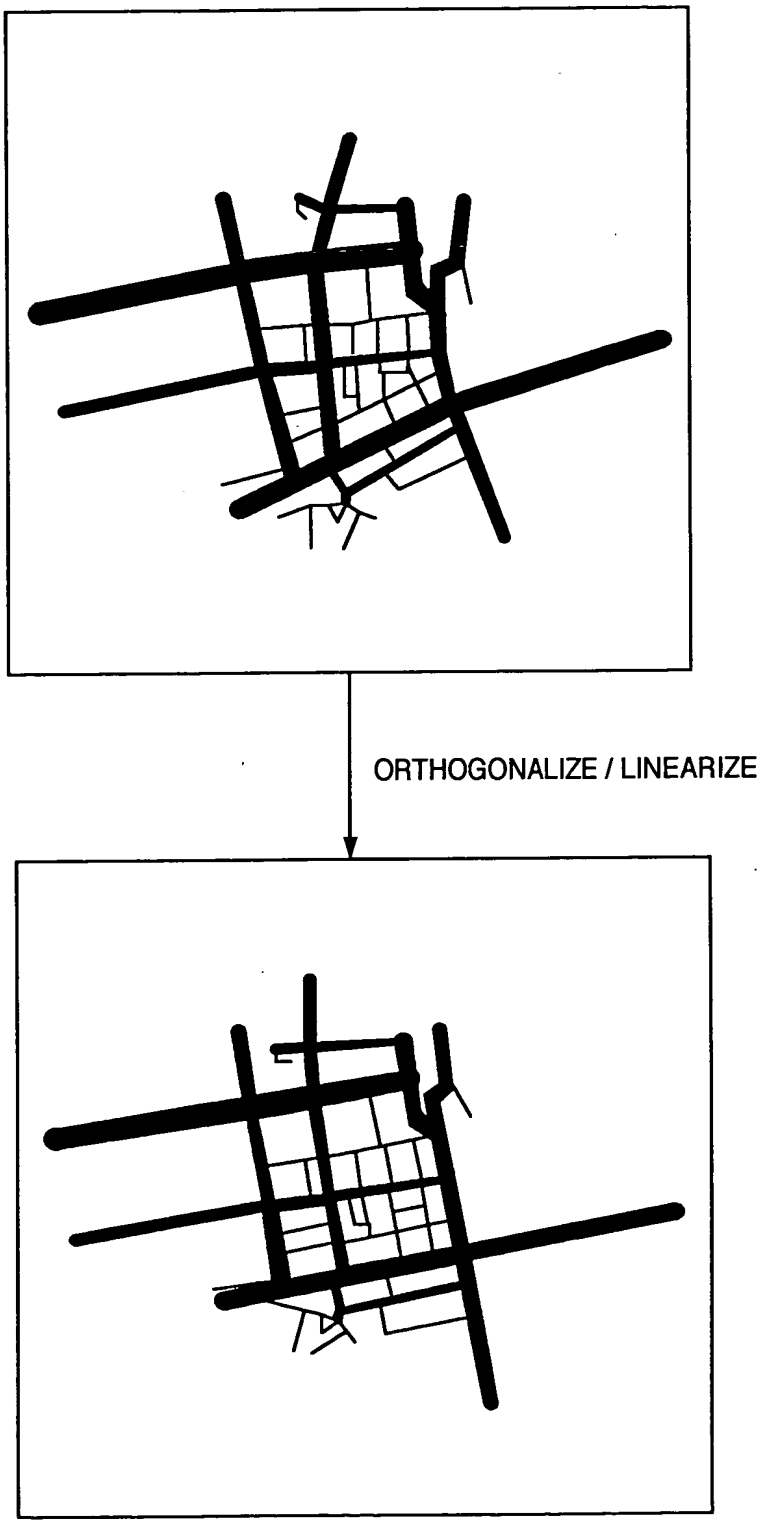


FIG.26

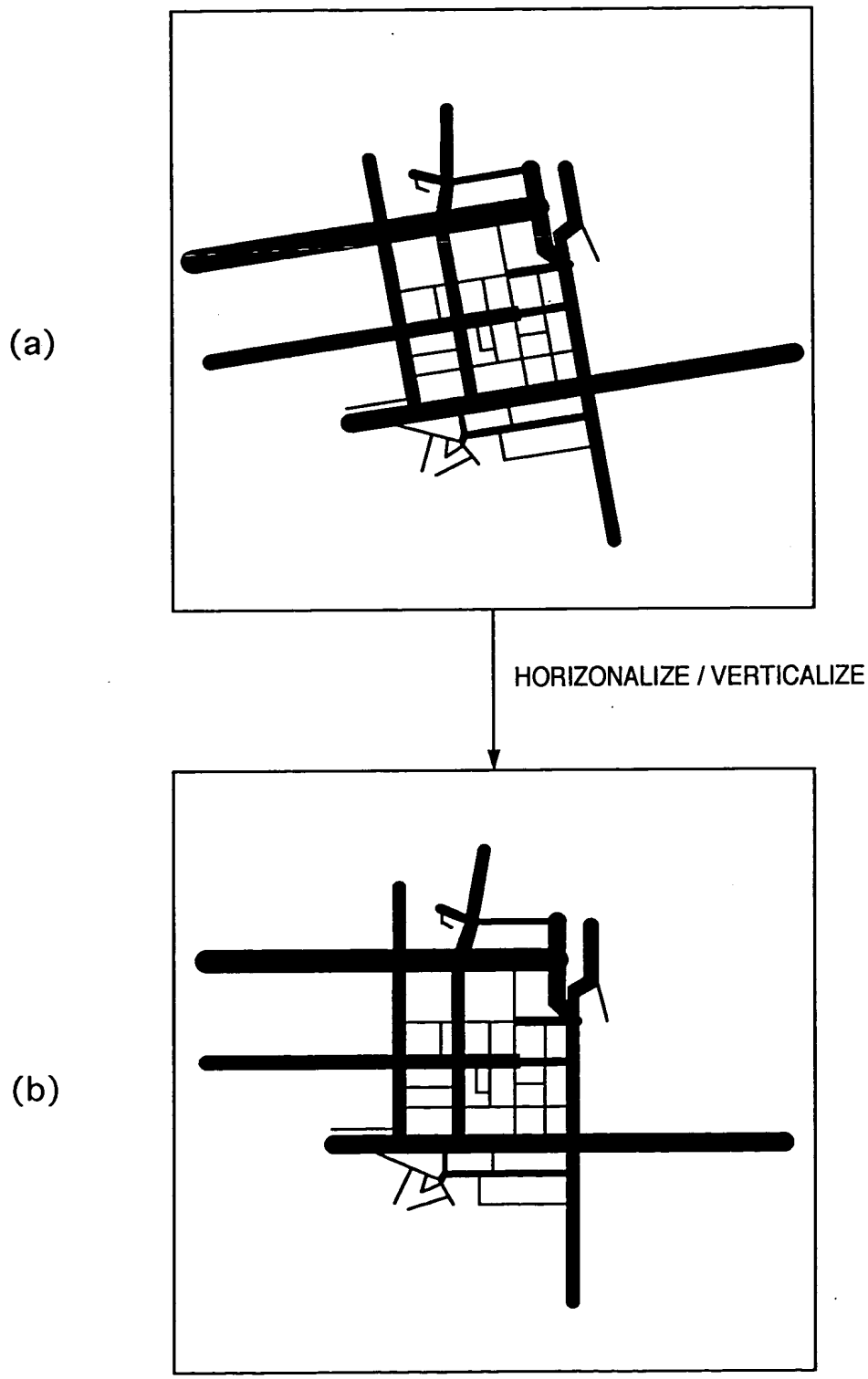


FIG.27

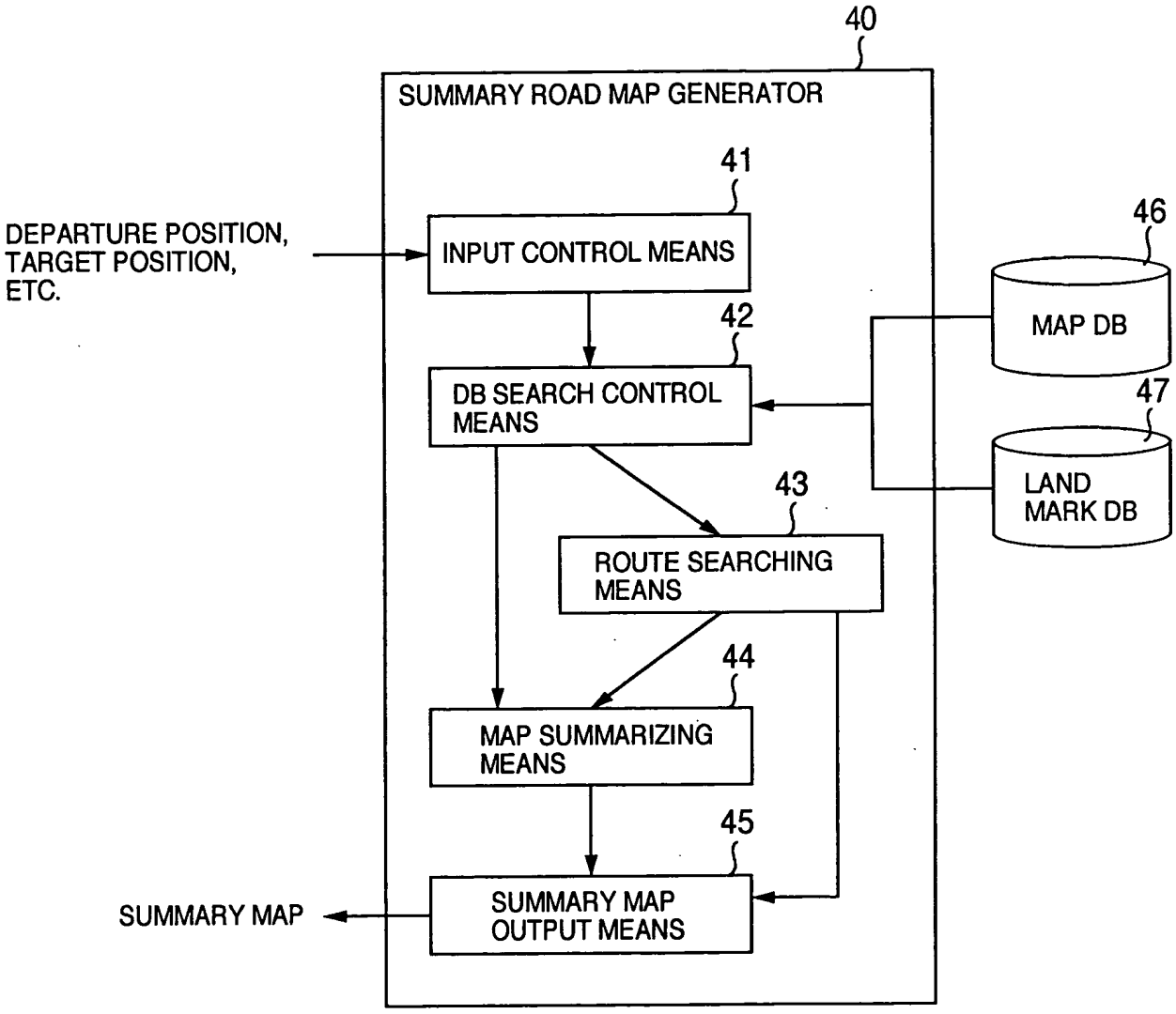

40
SUMMARY ROAD MAP GENERATOR
41
INPUT CONTROL MEANS
DEPARTURE POSITION,
TARGET POSITION,
ETC.
42
DB SEARCH CONTROL MEANS
43
ROUTE SEARCHING MEANS
44
MAP SUMMARIZING MEANS
45
SUMMARY MAP OUTPUT MEANS
SUMMARY MAP
46
MAP DB
47
LAND MARK DB

FIG.28

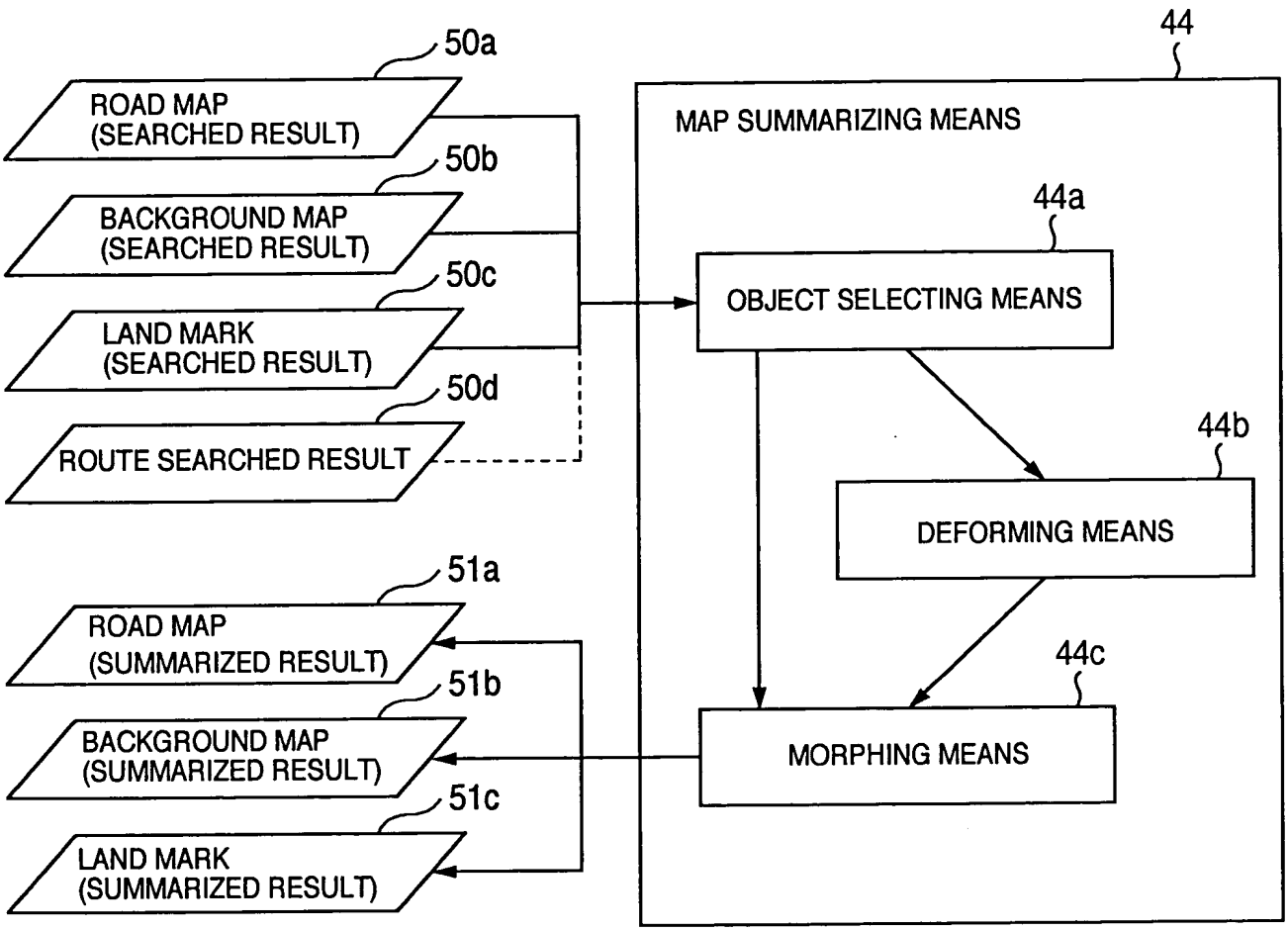

50a
ROAD MAP
(SEARCHED RESULT)
50b
BACKGROUND MAP
(SEARCHED RESULT)
50c
LAND MARK
(SEARCHED RESULT)
50d
ROUTE SEARCHED RESULT
51a
ROAD MAP
(SUMMARIZED RESULT)
51b
BACKGROUND MAP
(SUMMARIZED RESULT)
51c
LAND MARK
(SUMMARIZED RESULT)
44
MAP SUMMARIZING MEANS
44a
OBJECT SELECTING MEANS
44b
DEFORMING MEANS
44c
MORPHING MEANS

FIG.29

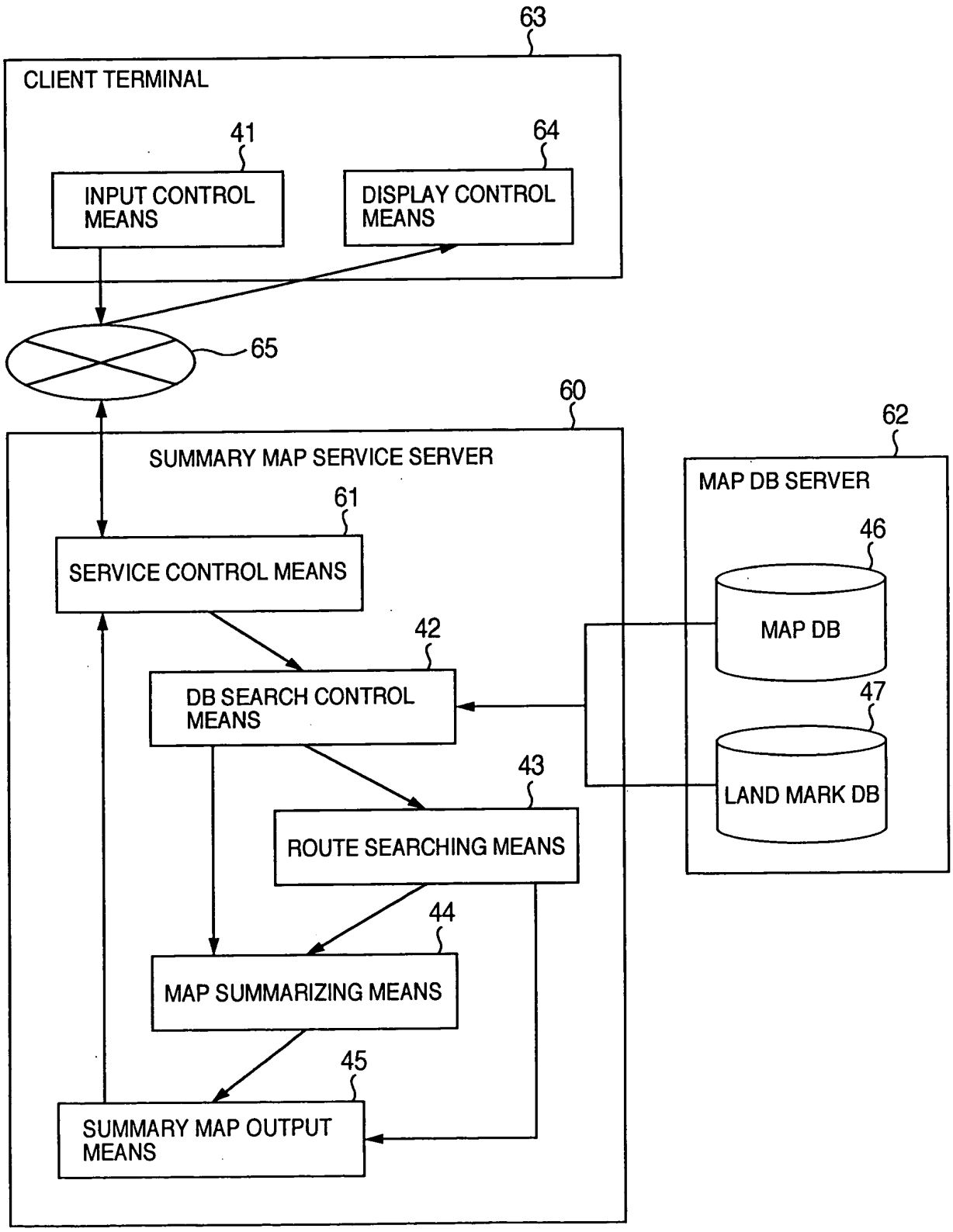

63
CLIENT TERMINAL
41
INPUT CONTROL MEANS
64
DISPLAY CONTROL MEANS
65
60
SUMMARY MAP SERVICE SERVER
61
SERVICE CONTROL MEANS
42
DB SEARCH CONTROL MEANS
43
ROUTE SEARCHING MEANS
44
MAP SUMMARIZING MEANS
45
SUMMARY MAP OUTPUT MEANS
62
MAP DB SERVER
46
MAP DB
47
LAND MARK DB

FIG.30

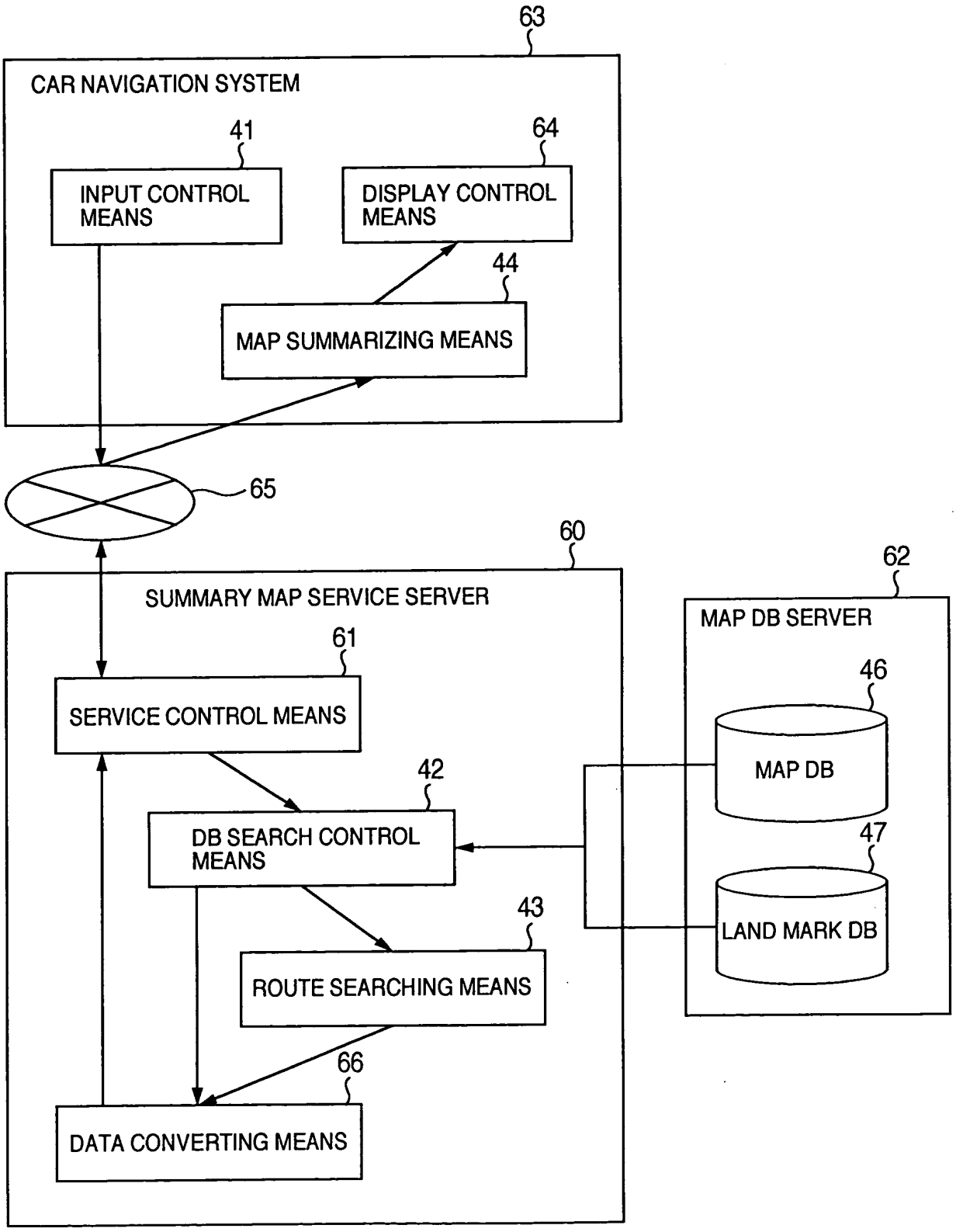

63
CAR NAVIGATION SYSTEM
41
INPUT CONTROL MEANS
64
DISPLAY CONTROL MEANS
44
MAP SUMMARIZING MEANS
65
60
SUMMARY MAP SERVICE SERVER
61
SERVICE CONTROL MEANS
42
DB SEARCH CONTROL MEANS
43
ROUTE SEARCHING MEANS
66
DATA CONVERTING MEANS
62
MAP DB SERVER
46
MAP DB
47
LAND MARK DB

FIG.31

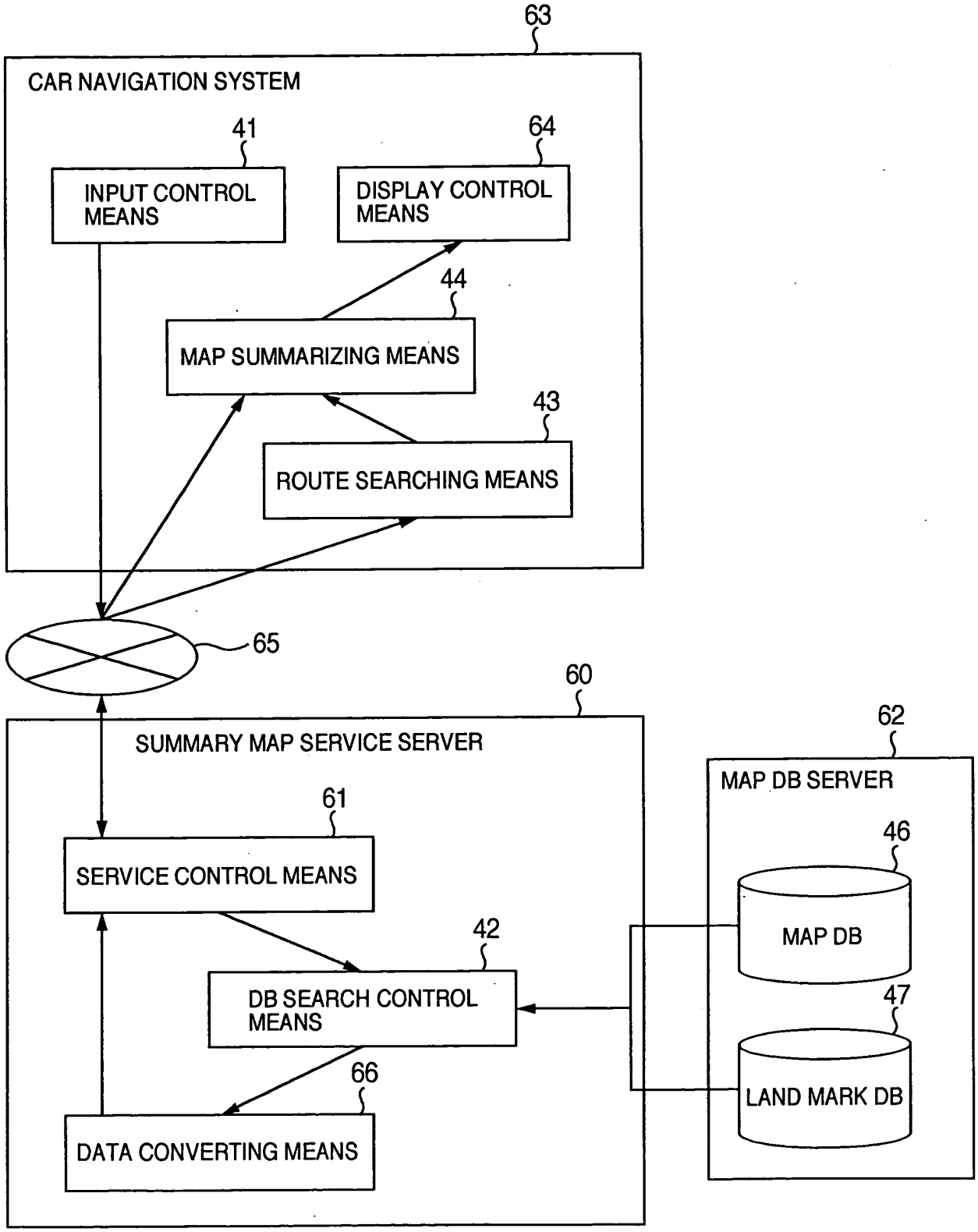

63
CAR NAVIGATION SYSTEM
41
INPUT CONTROL MEANS
64
DISPLAY CONTROL MEANS
44
MAP SUMMARIZING MEANS
43
ROUTE SEARCHING MEANS
65
60
SUMMARY MAP SERVICE SERVER
61
SERVICE CONTROL MEANS
42
DB SEARCH CONTROL MEANS
66
DATA CONVERTING MEANS
62
MAP DB SERVER
46
MAP DB
47
LAND MARK DB

FIG.32

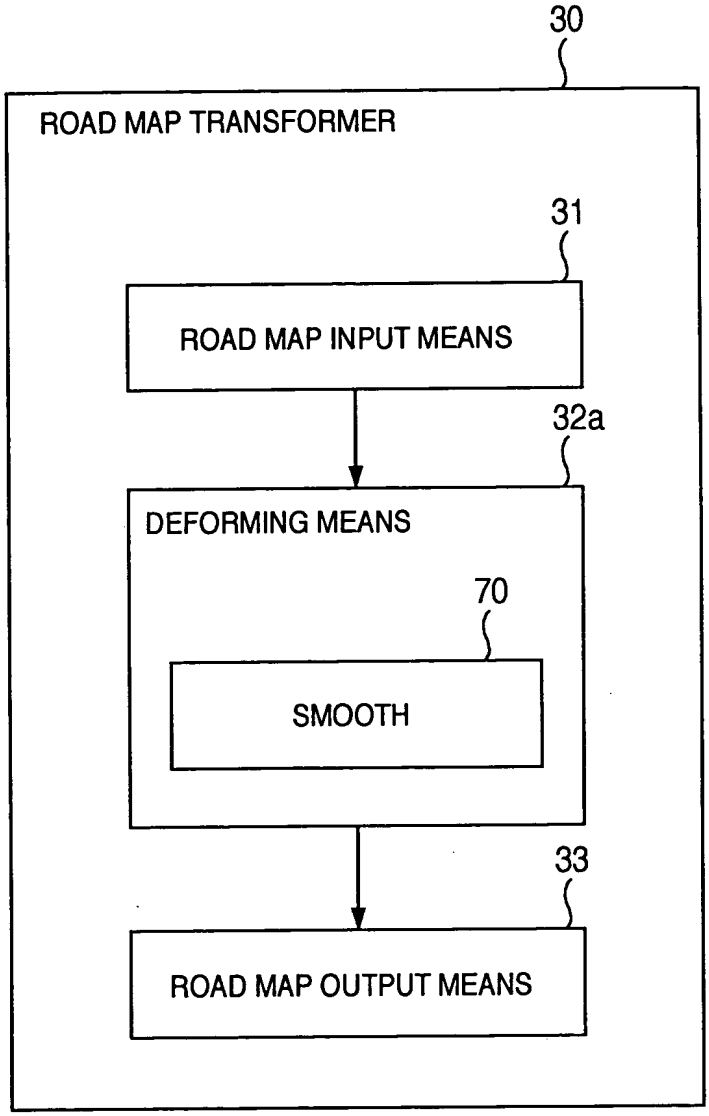

30
ROAD MAP TRANSFORMER
31
ROAD MAP INPUT MEANS
32a
DEFORMING MEANS
70
SMOOTH
33
ROAD MAP OUTPUT MEANS

FIG.33

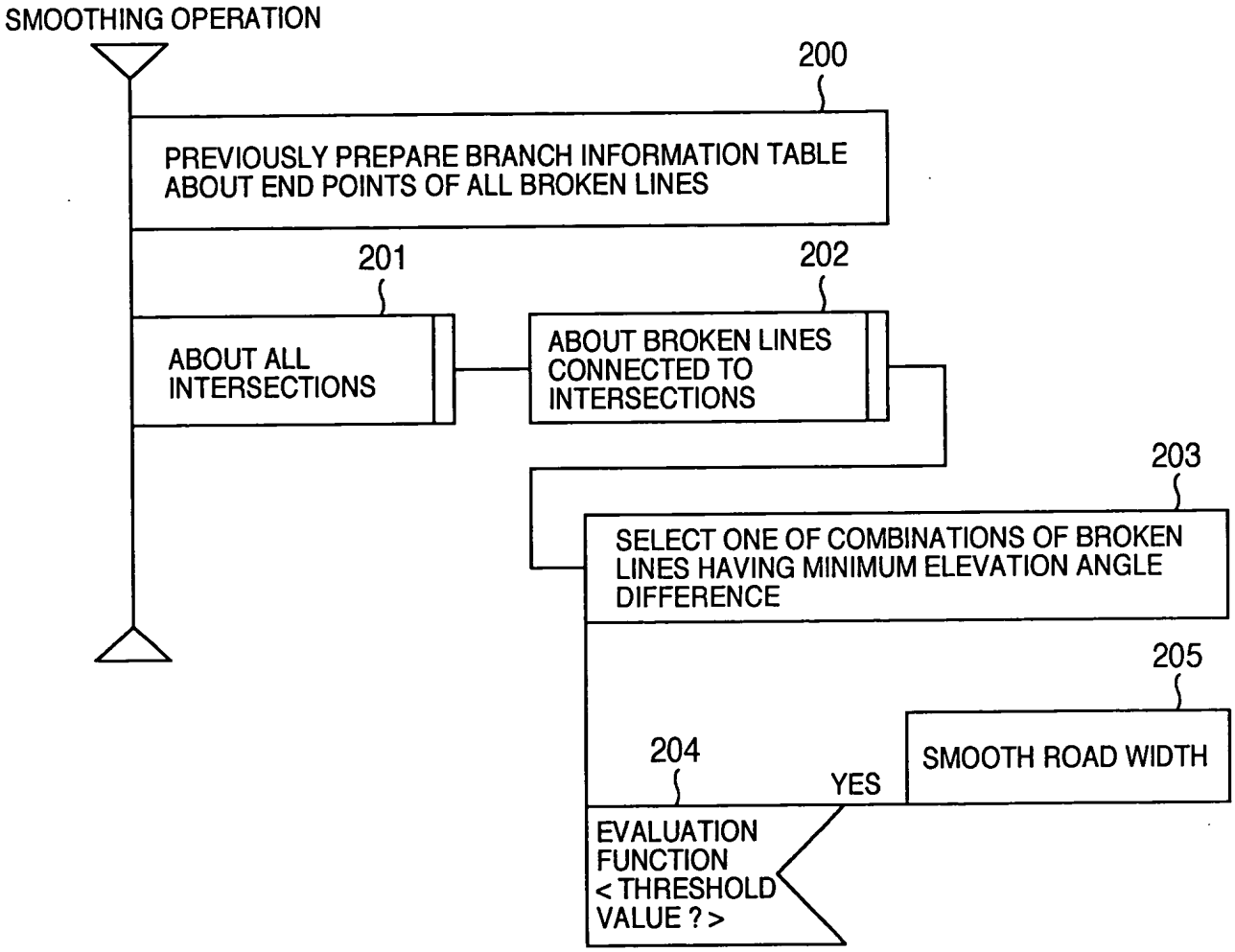

SMOOTHING OPERATION
200
PREVIOUSLY PREPARE BRANCH INFORMATION TABLE ABOUT END POINTS OF ALL BROKEN LINES
201
ABOUT ALL INTERSECTIONS
202
ABOUT BROKEN LINES CONNECTED TO INTERSECTIONS
203
SELECT ONE OF COMBINATIONS OF BROKEN LINES HAVING MINIMUM ELEVATION ANGLE DIFFERENCE
205
SMOOTH ROAD WIDTH
204
YES
EVALUATION FUNCTION < THRESHOLD VALUE ? >

FIG.34

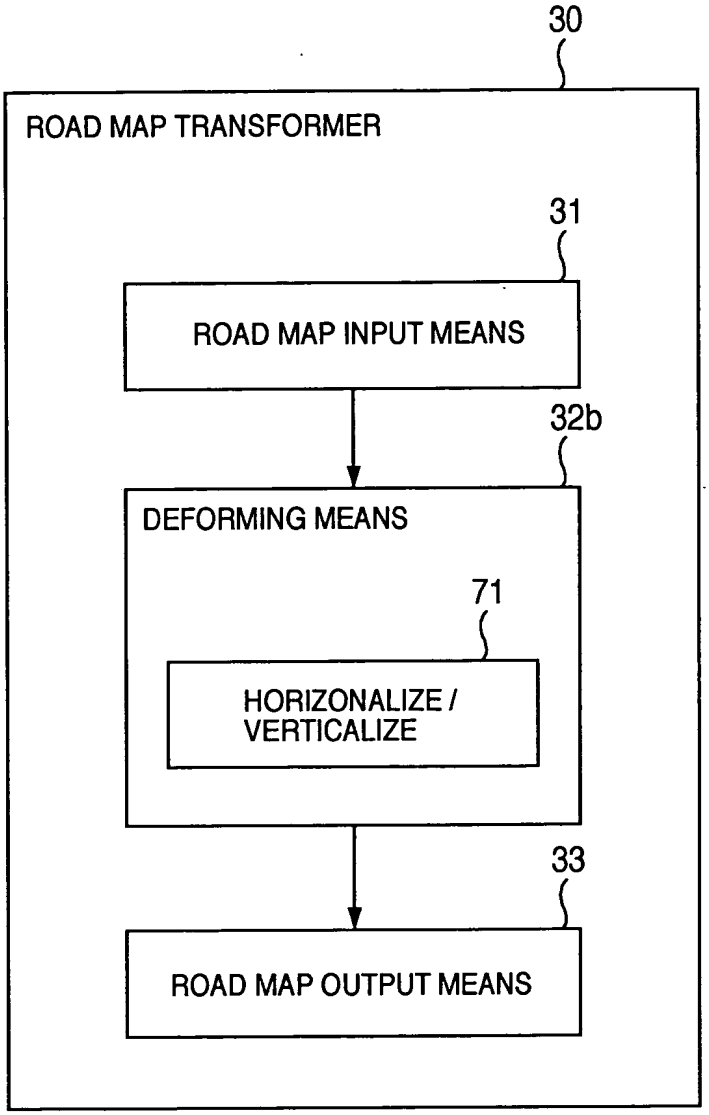
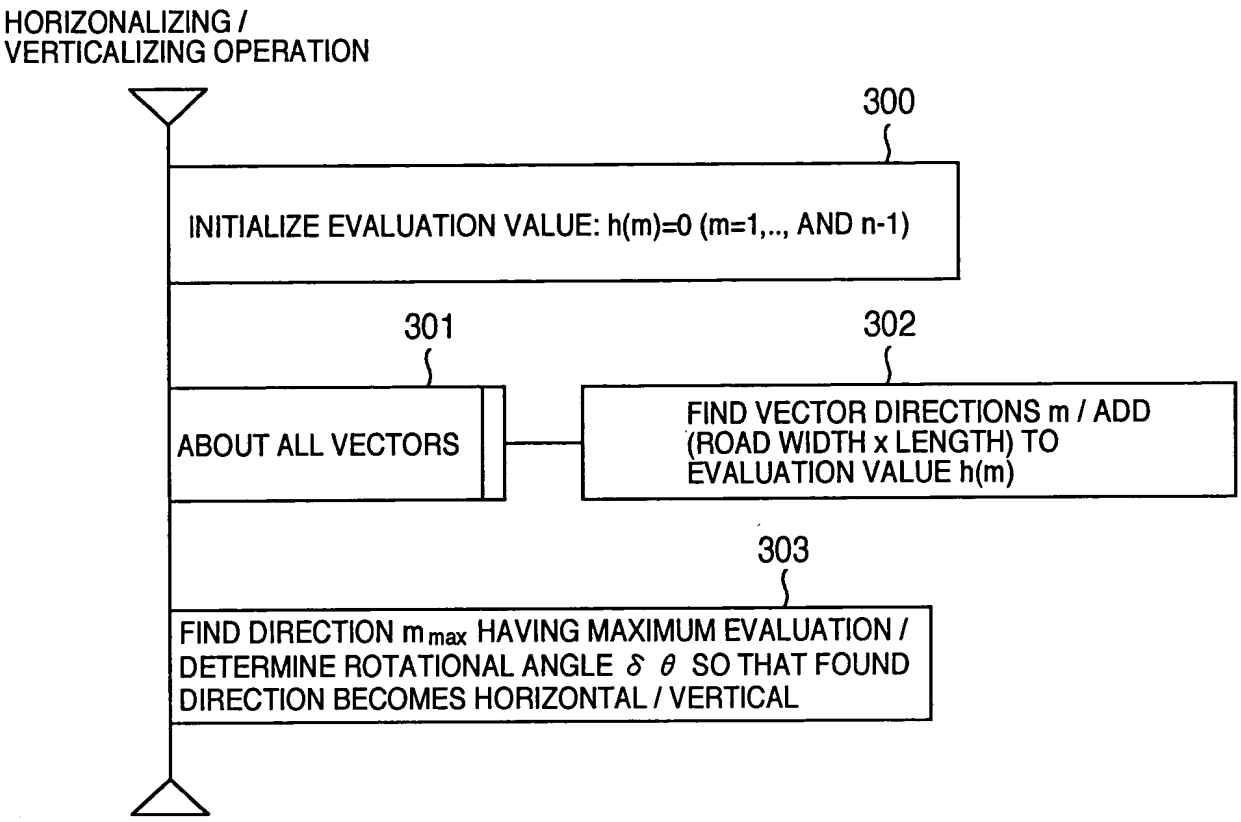

30
ROAD MAP TRANSFORMER
31
ROAD MAP INPUT MEANS
32b
DEFORMING MEANS
71
HORIZONALIZE / VERTICALIZE
33
ROAD MAP OUTPUT MEANS

FIG.35


HORIZONALIZING / VERTICALIZING OPERATION
300
INITIALIZE EVALUATION VALUE: h(m)=0 (m=1,.., AND n-1)
301
ABOUT ALL VECTORS
302
FIND VECTOR DIRECTIONS m / ADD (ROAD WIDTH x LENGTH) TO EVALUATION VALUE h(m)
303
FIND DIRECTION m max HAVING MAXIMUM EVALUATION / DETERMINE ROTATIONAL ANGLE δ θ SO THAT FOUND DIRECTION BECOMES HORIZONTAL / VERTICAL